dAu Phi to ee Analysis Note V2

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Abstract

We describe the measurement of the phi meson decaying to electron pairs in dAu data using the PHENIX spectrometer. The sample used requires the "ERT" trigger where the threshold is set to 600 MeV (about ½ the run). Depending on cuts we have a sample of ~100 phi to ee.

Status

- Invariant mass spectra converging (Yuji, RKS, Sasha K)
- Backgrounds done
  - Using sideband subtraction
    - Several varieties
  - Using polynomial fits
  - ERT triggers
- MC completed
  - Acceptance done
  - Trigger eff done
- Yieds calculated
- Systematic errors calculated

- Changes
  - Jan 3 – extensive revision – Acc/trigger now done with PISA
  - Jan 4- just fixed some wording, made some pictures a bit nicer
  - Jan 5
    - for signal counting use +- 3 sigma, where sigma is as in min bias (note the last bin with the largest sigma is dropped)
    - Make a better comparison with the polynomial fit where fit is stable
    - Make some plots nicer
    - Add some more on systematics

Outline

- Introduction
- Data sample
- Track/Electron ID
- Ghost tracks
- Procedure using triggered data
- QA
- Invariant mass spectra
- Signal (background) extraction
- Fitting
- Mt-m0 binning
  - 0-.25,.25-.75,.75-1.25
  - 1.25-5.0 was dropped
- Simulations
- Acceptance
- Trigger efficiencies
- Run by run corrections
- Yields
- Systematic errors
- Comparison to KK result

I. Introduction

This analysis note describes the reconstruction of dielectron pairs in the region of the phi meson. The phi has a mass=1019.4 MeV and Γ=4.46 MeV and decays into two electrons with a BR=2.96×10^{-4}. (for reference the omega has m=782.6 MeV, Γ=8.44 MeV, BR(ee)=6.95×10^{-5}. We have benefited greatly from the previous analysis, both for di-electrons and for the KK decay of the phi. In particular we will attempt to follow most of the same procedures of the J/psi analysis, departing only when it is of benefit. All the data used for the primary spectrum came in under the ERT trigger. We will use this to get a preliminary measurement of the minimum bias yield of the phi decaying into di-electrons. This compared with the a similar analysis to the KK final state will be used to probe the possible changes in the masses or widths of the phi and/or kaons due to chiral symmetry restoration.

Data Set used in the analysis

All the data analysis is done ERT_Electron trigger events. The threshold was set to 600 MeV during the first running period, and 800 MeV during the second. Because of the low Q value of the phi to ee we choose the period with the threshold set at 600 MeV. This has the advantage the turn on curve of the ERT seems better understood. As is standard in much of the phenix analysis we used events with |bbcZ|<30cm.

Throughout this note, we use “MB equivalent” as measure of the integrated luminosity used in the analysis. It is defined as:

MB_samples = N_MB(|bbcZ|<30cm) * MB_pre_scale

N_MB(|bbc_Z|<30cm) : the number of the recorded min. bias events within |bbcZ|<30cm

MB_pre_scale: pre-scale factor for the min. bias trigger (BBCLL1>=1)

The statistics for the relevant running period after removing bad runs and converter runs are:

67219 <= run < 78312 (1.9×10^9 MB equivalent within |bbcz|<30cm. This is slightly more than the J/psi folks since we do not exclude some of the runs which give them abnormal numbers of like sign pairs in the J/psi mass region-

Also note that there are 1.8×10^9 MB equivalent within |bbcz|<30cm in the running period where the threshold was set to 800 MeV

The data sample analyzed were the reconstructed nDST’s for the electron working group I.e. EWG_electron- Pro.47.

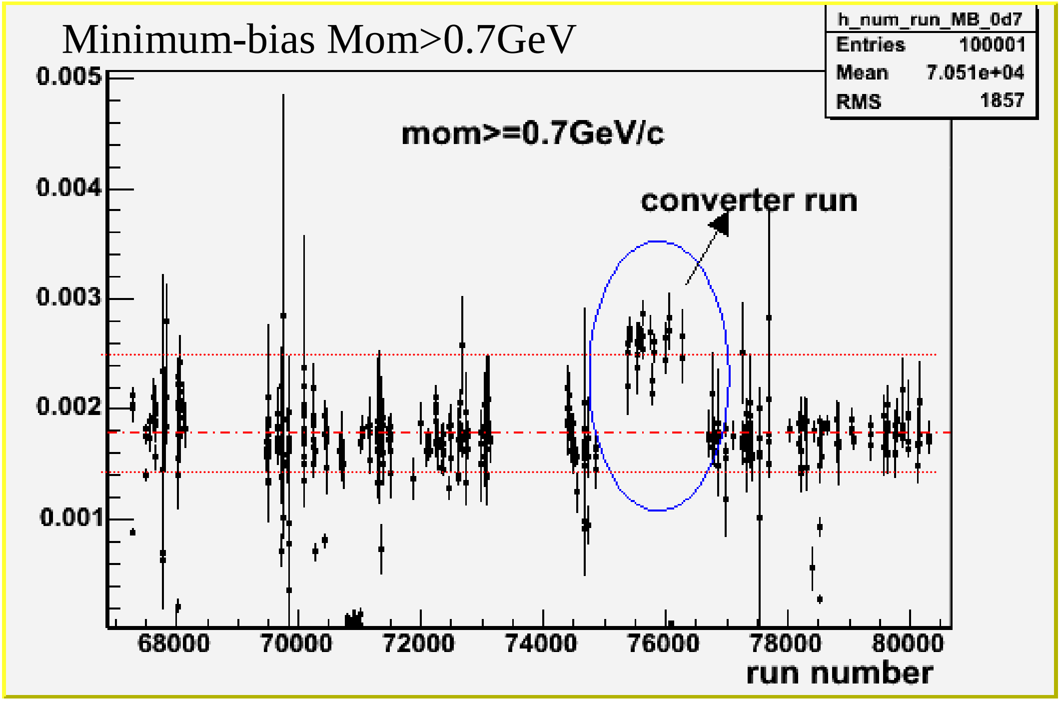
Event mixing on triggered data

One of the methods of getting the shape of the background is to use the mixed event method. In order to get the correct shape we use only minimum bias events. We then combine the electrons (positrons) from two different events of the same event class (where we divide the events into zvertex position and centrality as measured by the BBC). In order to simulate the effect of the trigger we require that one of the particles satisfy the ERT trigger condition, I.e.

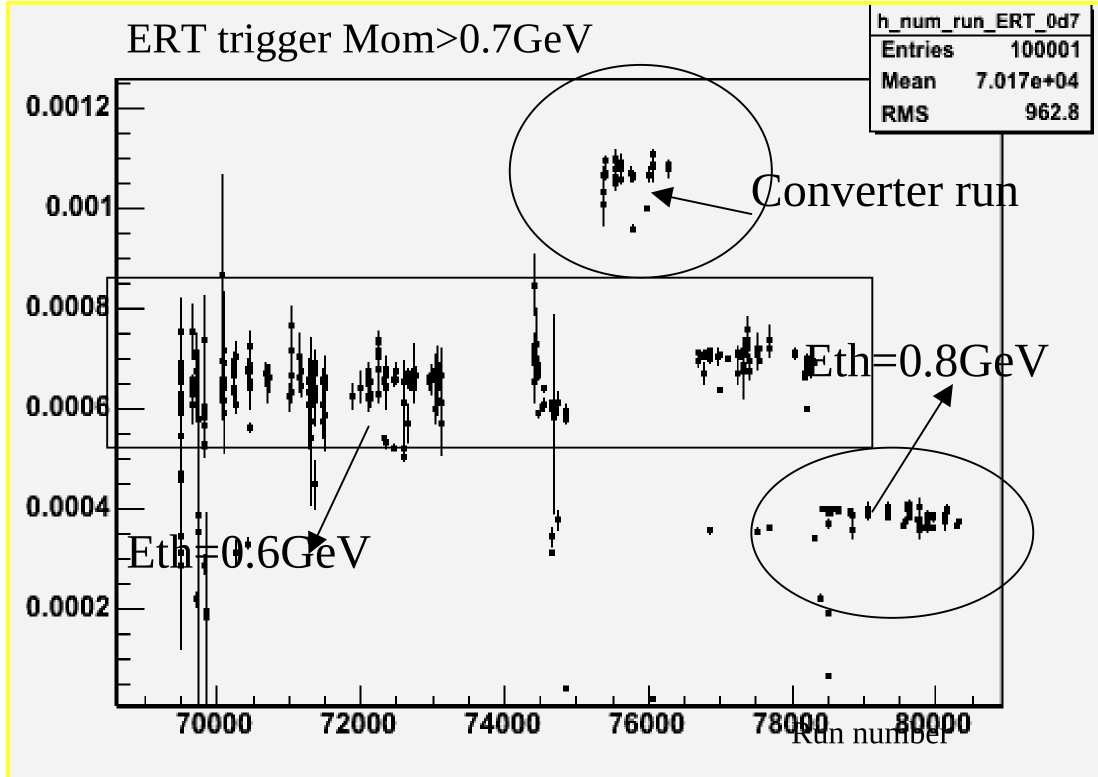
"in event#1, GL1 says ERT_electron trigger fires && e+ fired the trigger OR in event#2, GL1 says ERT_electron trigger fires && e- fired the trigger"

Electron QA in RUN3 d-Au

We rejected the identical set of runs for quality assurance reasons as did the J/psi analysis. The number The standard to reject bad runs is defined for non-converter runs is: *Mean +error(stat)<0.0014 .OR. Mean-error(stat)>0.0024* , where mean is the mean value of number of electrons in a run and error is the statistical error of the mean.. For converter runs, higher value of boundary is set. The rejected runs are listed in the appendix of the J/Psi analysis note.

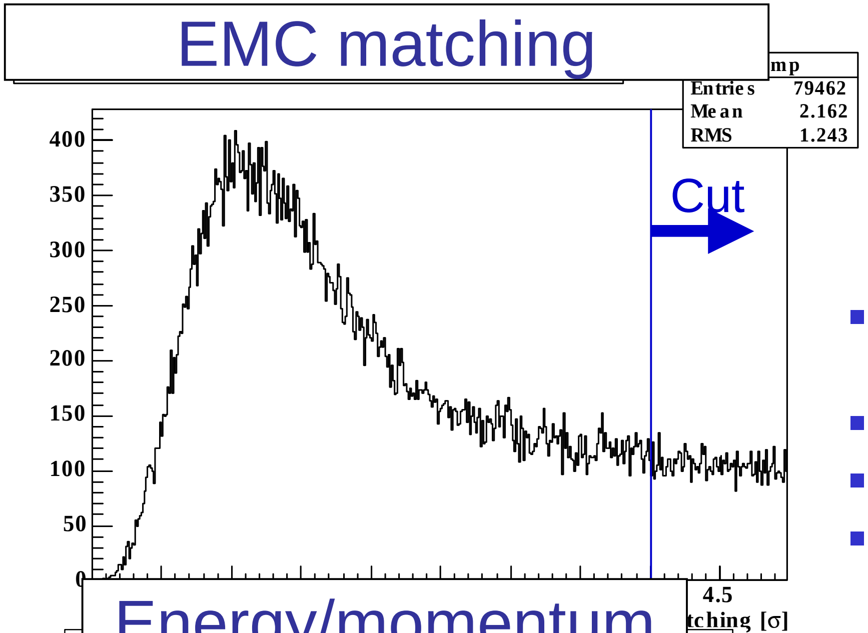


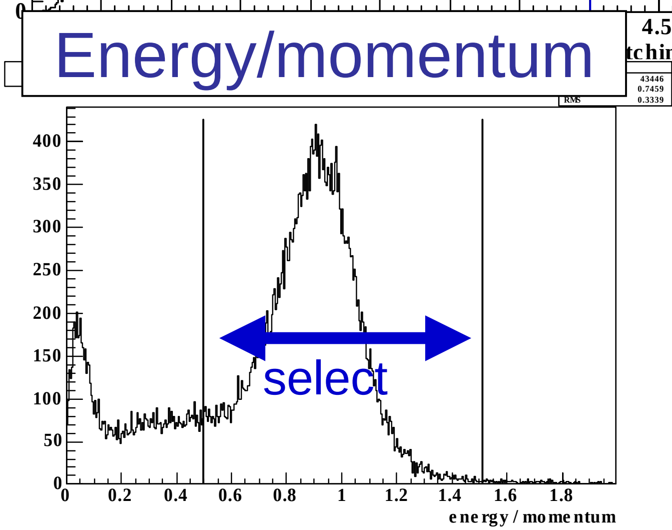
. Shown also is the result for ERT_electron trigger, similar cut is applied with boundary set to be between 0.0004-0.0008 for no-converter runs.



. Note that a cut is made at 700 MeV for this study. This would ordinarily not be done in the case of the phi, since many of the electrons from phi decay would be of lower energy, but we assume that whatever problems gave rise the the unusual ratio's in this study would reject problems for all electrons. The figure on the left shows the ratio for the MB events.

Electron identification





We used very loose cut in order to take more statistics, and to make estimation of eID easy

- EMC matching < 4σ

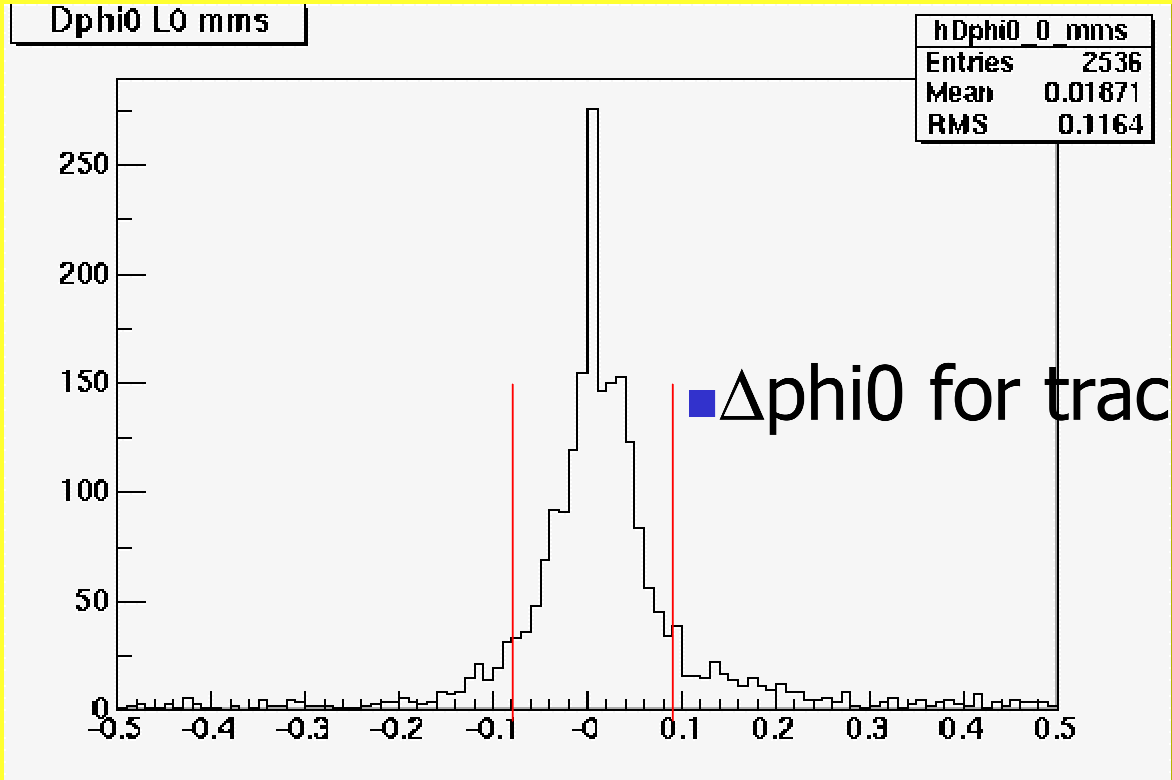
$$\text{Matching} = \sqrt{\delta\varphi^2 + \delta z^2}$$

- 0.5 < E/p < 1.5
- n0>=2
- Ghost track cut
  - kill worse matching track If dzed<1 & dphi<0.1
- RICH ring sharing cut
  - Kill one track if dc_zed<10 & dc_phi<0.1 randomly

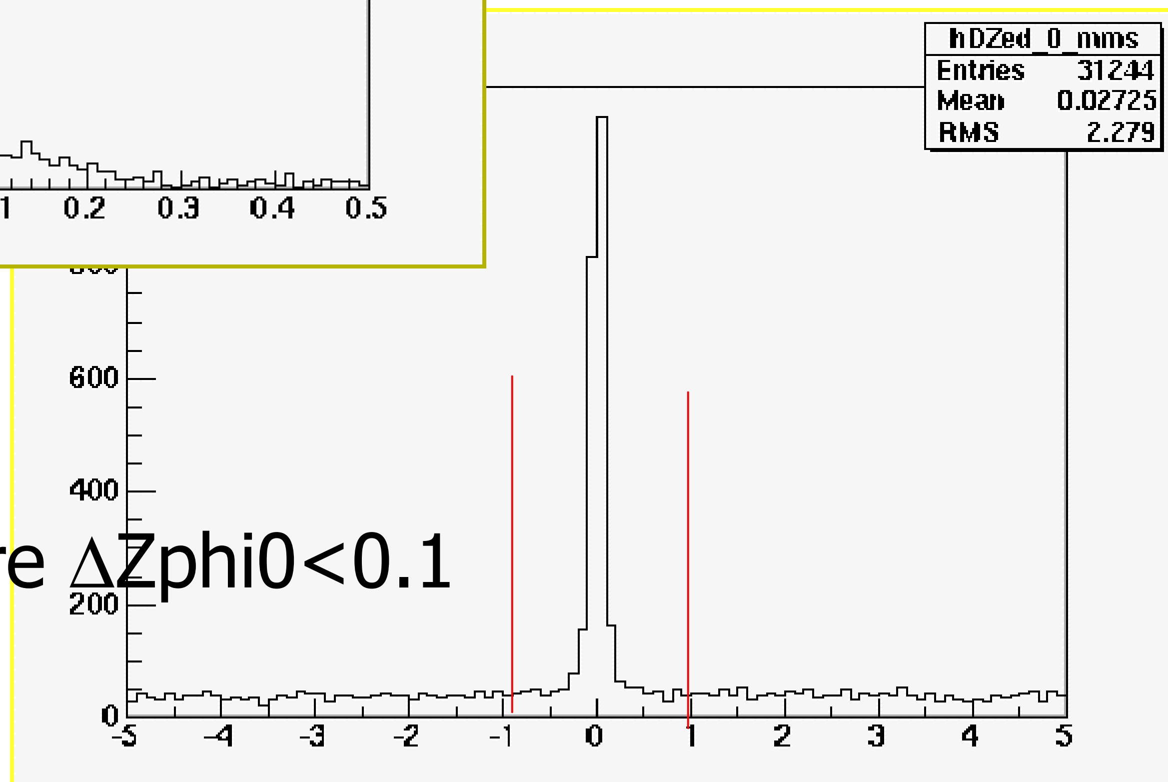
Ghosting plots

We encountered two types of ghosts. The first are essentially tracks which are duplicated. The second are particle identification ghosts in which two tracks are both identified as electrons even though only one should be- often called “ring sharing”. These cause a problem for the mixed event background techniques since they introduce additional correlations into the sample.

Track ghosts share a close zed and phi0 from the drift chamber as in the figures on the next page. Initially each event is checked for ghosts defined as two tracks which are within ΔZed<1cm and Δphi0<0.1 rad. Note that the ΔZed should be made tighter in the future. When a ghost is encountered, one of the tracks is eliminated at random from any future analysis – that is, it cannot participate in mixed event analysis as well as same-event analysis.



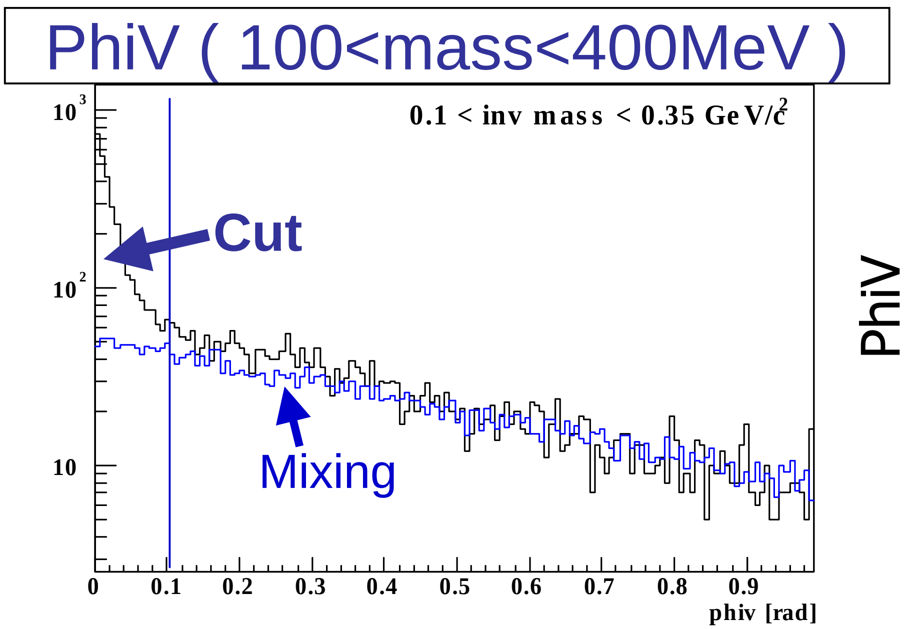
- Δphi0 for tracks where ΔZed<0.1

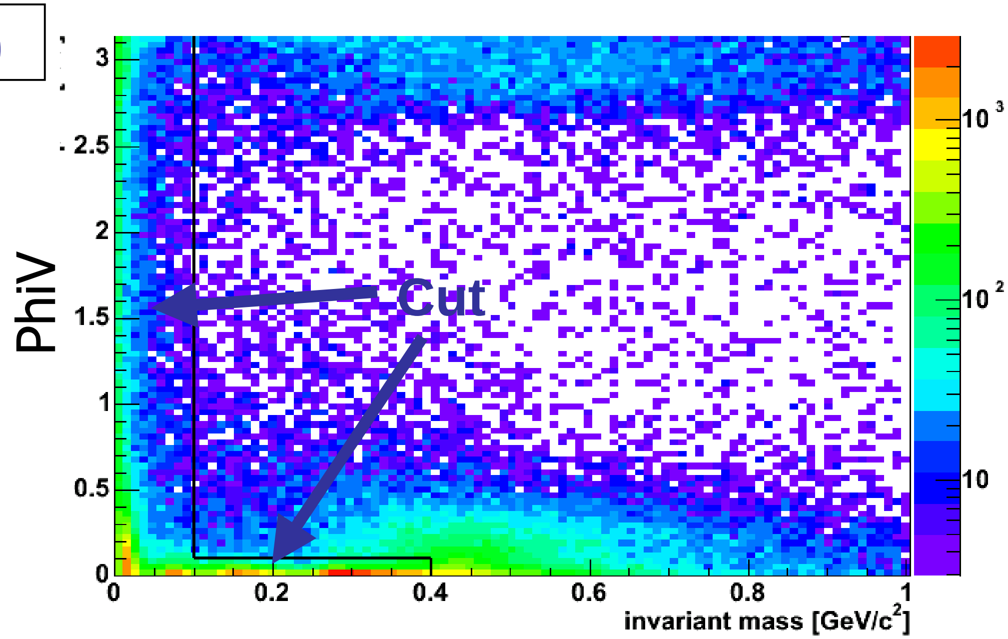


- ΔZed for tracks where ΔZphi0<0.1

Conversion Rejection by invariant mass and PhiV

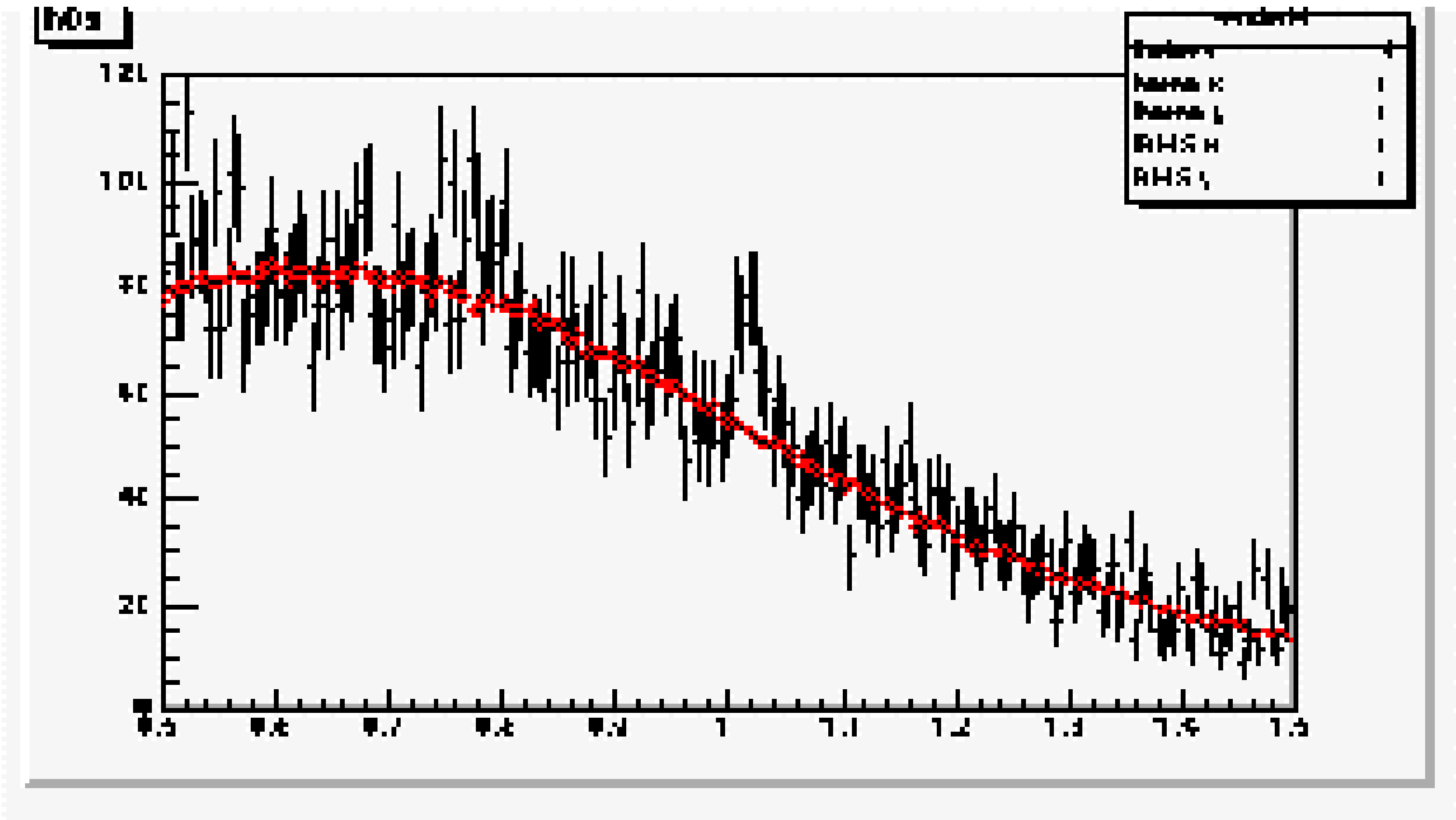
- e+e- pair from photon conversion has small phiv and small mass.we cut those pairs at low-background region
  - Kill all tracks if PhiV<0.1 for mass<400MeV
  - Kill all tracks if mass<100MeV





Invariant mass spectra

Once we have chosen good runs, identified electrons, and rejected ghosts and conversions we are in a position to look at the invariant mass spectra and the mixed event background as shown in the figure where a clear phi is visible, as well as the omega.



Signal extraction and background

The shape of the background can be well reproduced by the event mixing technique where the events are split up into classes of centrality as defined by the BBC and the zvertex. As mentioned previously, because we are using triggered events, care must be taken that the mixed background have the same characteristics as the the events themselves. Specifically we do the following:

- 2000 events in pool
  - require zvtx<2.cm difference,
  - 4 bins centrality, 0-10, 10-20,20-40.,40-100
- Use only MB events
- Require 1 to pass ERT matching cut (EMC+RICH)

Normalization

- Normalization proved to be a problem. We have chosen to use two methods. The first is to use the mixed event background and normalize it to “sidebands” where there is presumably little or no signal. These sidebands were selected to be between 500-600, and 1100-1200 MeV for opposite arms, and between 850 -950 and 1100-1200 for same arm. This avoided a mixing mismatch around 500MeV in the same arm which presumably comes from real pairs converting in the detector. We note that the standard method of normalizing to the combination 2sqrt(N++N--) over subtracted the background by ~10%.
- We compare this to a more standard sideband method which normalizes in the region immediately around the phi namely 0.85-0.95 and 1.1-1.2 GeV
- A second method did not used the mixed event background. Since the signal is a sharp peak this allows us to simply fit the spectrum to a relativistic breit-wigner together with a polynomial background. Neither of the two techniques employed here will work to identify a continuum background, or even the rho meson which is too broad. They are useful for cases in which the signal has a narrow structure.
- The first technique will be the one emphasized in this note, however the results of the more standard sideband normalization and the polynomial fit will be used as a measure of the systematic background in extracting the signal.

Fitting- the relativistic breit-wigner

- The peak is fit to a relativistic Breit Wigner convoluted with a Gaussian for the experimental resolution with an an arbitrary normalization A. Here m_0=mass of the phi, Γ_0= width of the phi held fixed at the PDG value of .00446 GeV, σ_m the experimental mass resolution and m is the di-electron invariant mass

$$\frac{dN_{e^+e^-}}{dm} = A\int_{m_2}^{m_1} \mathrm{RBW}(m')\frac{1}{\sqrt{2\pi\sigma_m^2}}\exp\left[-\frac{1}{2}(\frac{m-m'}{\sigma_m})^2\right]\,dm'$$

$$\begin{aligned}\mathrm{RBW}(m) &= \frac{mm_0\Gamma(m)}{(m^2-m_0^2)^2+(m_0\Gamma(m))^2},\\ \Gamma(m) &= 2\Gamma_0\frac{(q/q_0)^3}{(q/q_0)^2+1},\\ q &= \sqrt{m^2/4-m_e^2}.\end{aligned}$$

Fit

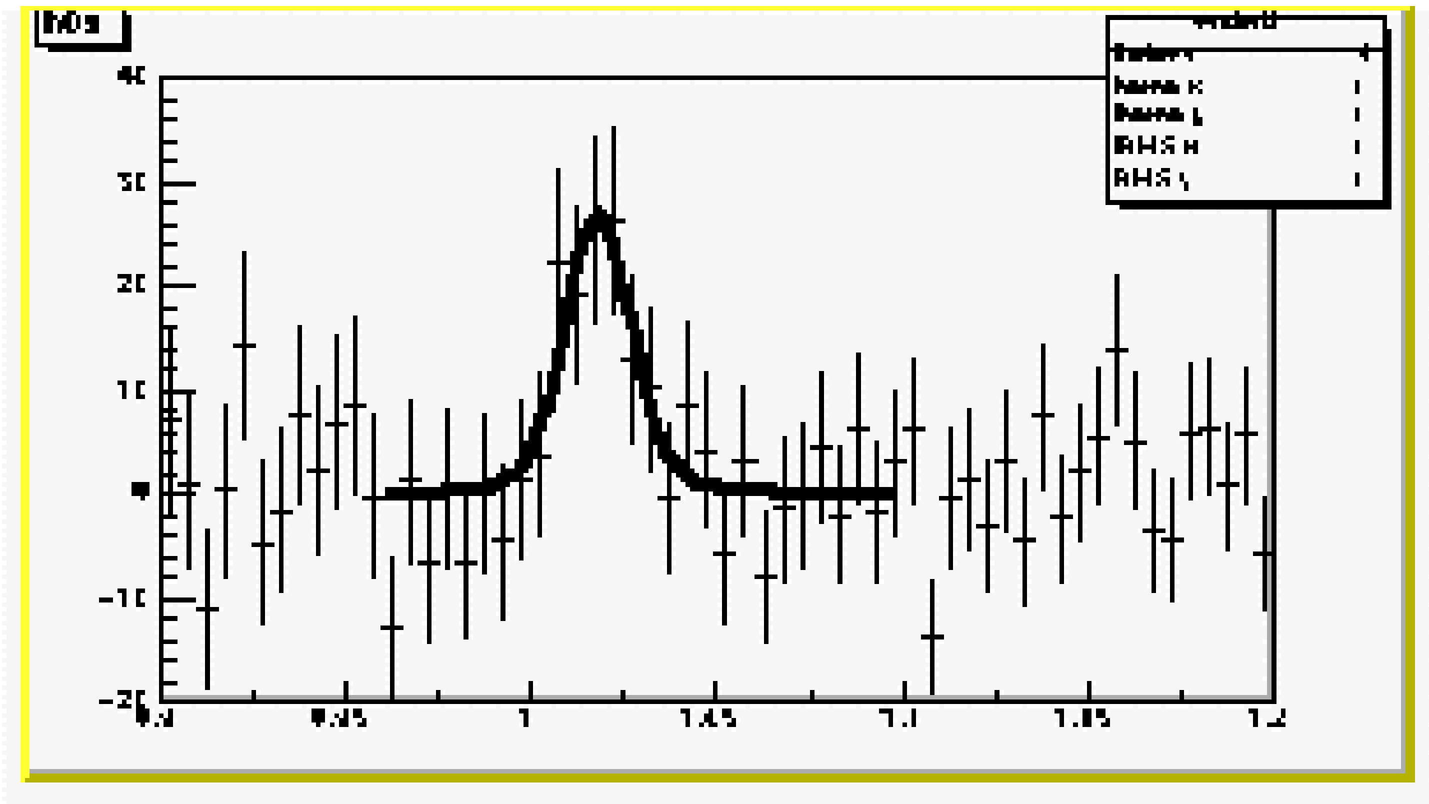
- Γ held fixed
- num of evt = 3.13e+07
- All 600 MeV threshold ERT triggers

m = 1.0177 ±0.0023 GeV

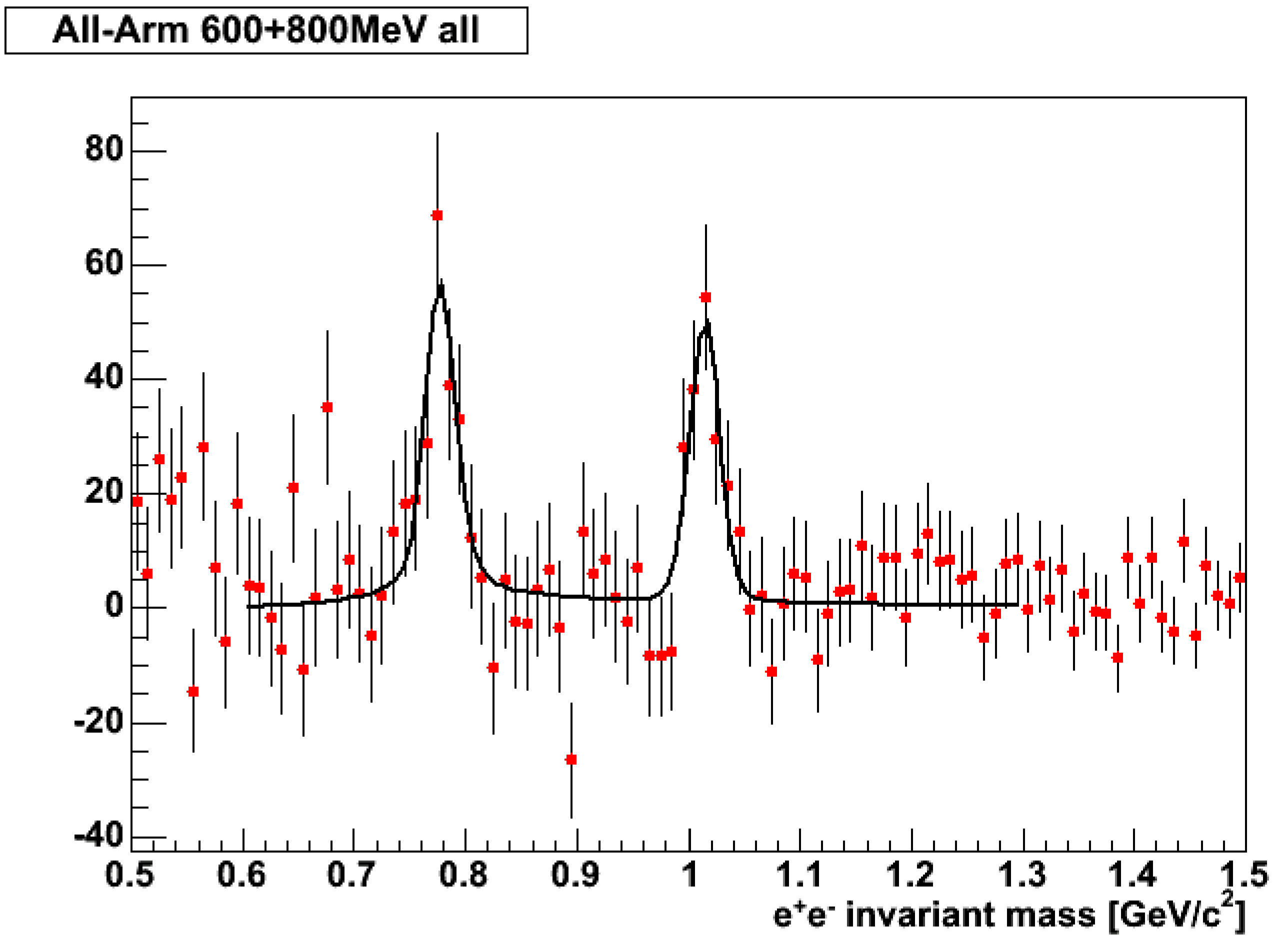
Γ = 0.004458 GeV

σ = 0.008 ±0.002 GeV

N=124 (3 σ)



Full data sample – the future



Signal counting and Mt bins

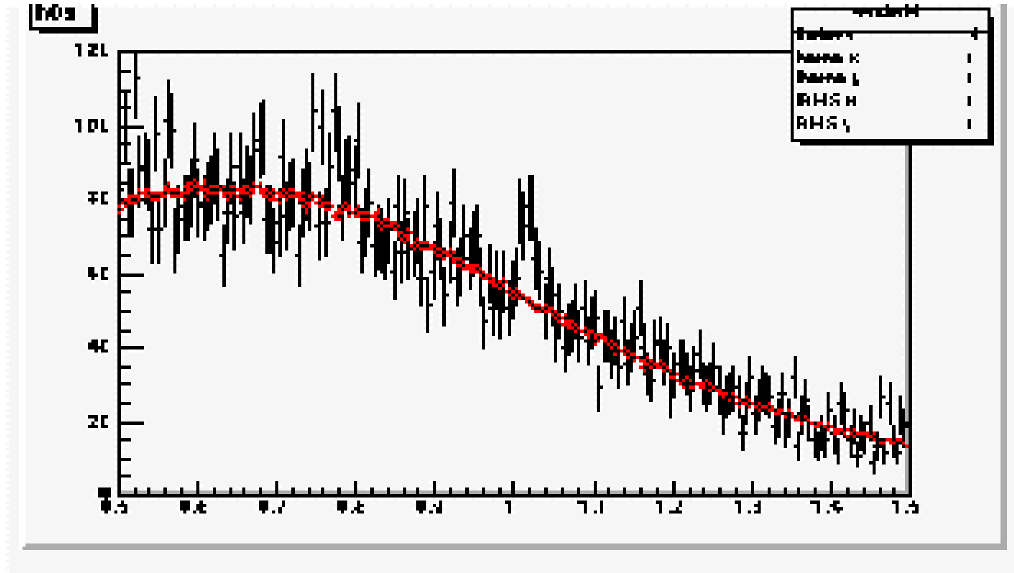
In all cases we extract the number of phi events by simply integrating over a region, typically 3 times the experimental mass resolution of ~10 MeV. Particularly when the data is split into bins of mt, there is not enough signal to determine the width accurately enough to be able to simply integrate the fit function. The region over which the summation is done is varied to estimate the systematic error. As before we hold the natural width (gamma) fixed at the PDG value. The fits are done primarily to set the 3 sigma width for the integration and to show consistency. In the fits for the individual mt bins, the mass is held constant to the value from the min bias fit.

We chose mt-m0 bins=(0-0.25)(0.25-0.75)(0.75-1.25)(1.25-2.50) where the 4^{th} bin still does not have enough data and is dropped

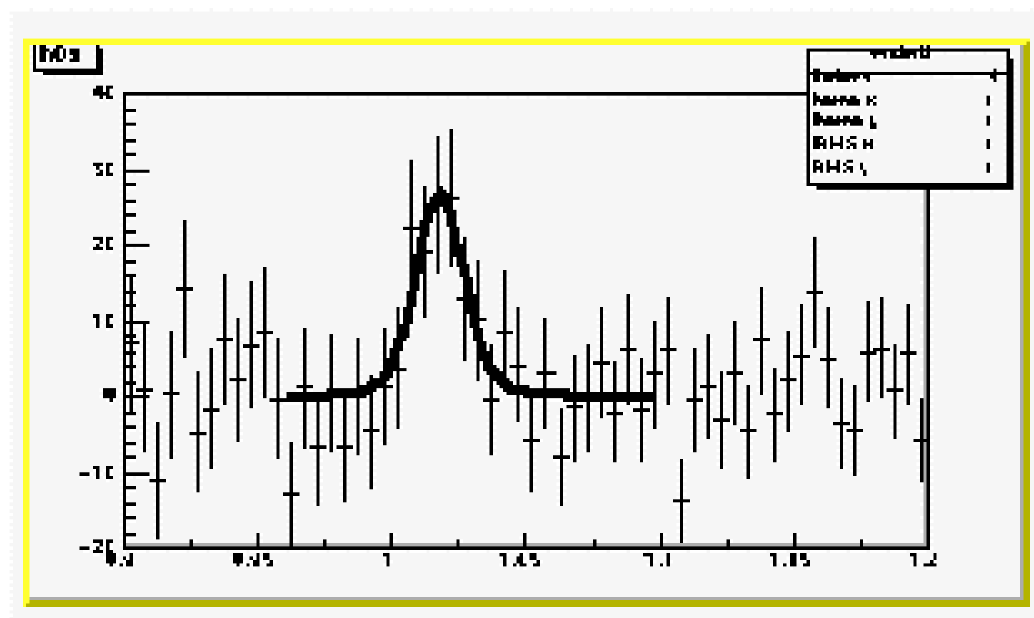
As mentioned before several methods were used to extract the numbers to determine the systematic error. (2 sideband normalizations and a polynomial fit to the background) Then several windows of integration were chosen. The standard will be a 3 sigma, but count from 2 and 4 sigma will be used to understand the systematic errors.

The fits shown here are only from the standard sideband method chosen for the analysis, with the counts coming from 3 sigma. A table then summarized the counts from the various methods. we have chosen to use for these limits the mass and sigma for the min bias data. The three bins we are looking at have simillar sigma values – see table
The values are mass=1.0177, sigma=.0081

All mt



- M=1.0177 $\pm$ 0.0023 GeV
- Γ=0.00446 (fixed) GeV
- σ_{mb}=0.0081 $\pm$ 0.0021
- χ^2/DOF=13.6/13
- $3\sigma_{mb}$: N=125.7 bkg=706
- $2\sigma_{mb}$: N=120.5 bkg=490
- $4\sigma_{mb}$: N=124.1 bkg=861



- In this and all subsequent plots N indicates the number of counts within +- 3,2,4σ. We will use the 3 σ value as the standard

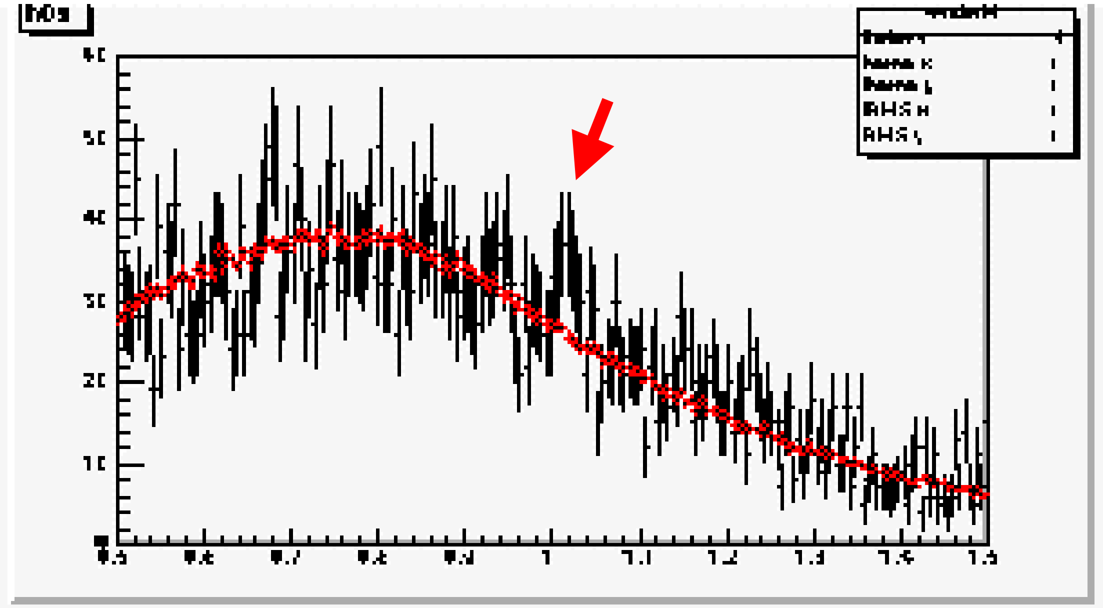
Make pretty plots

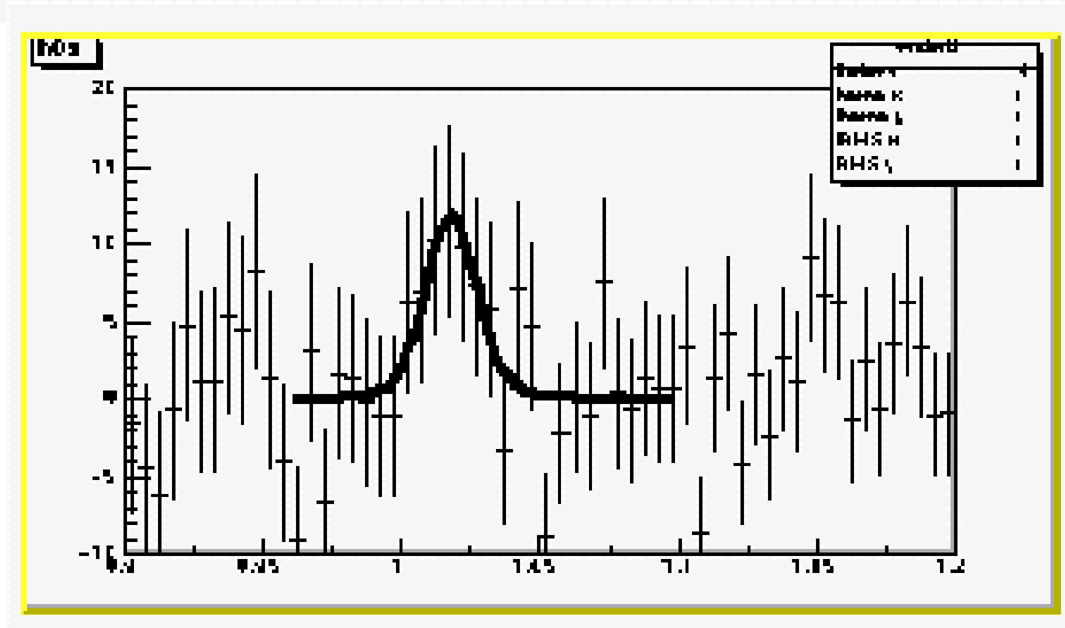
Request prelim

(pt1) M_T-m_0=0.0-0.25

- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.0084 ± 0.0032
- χ^2/DOF=18/13

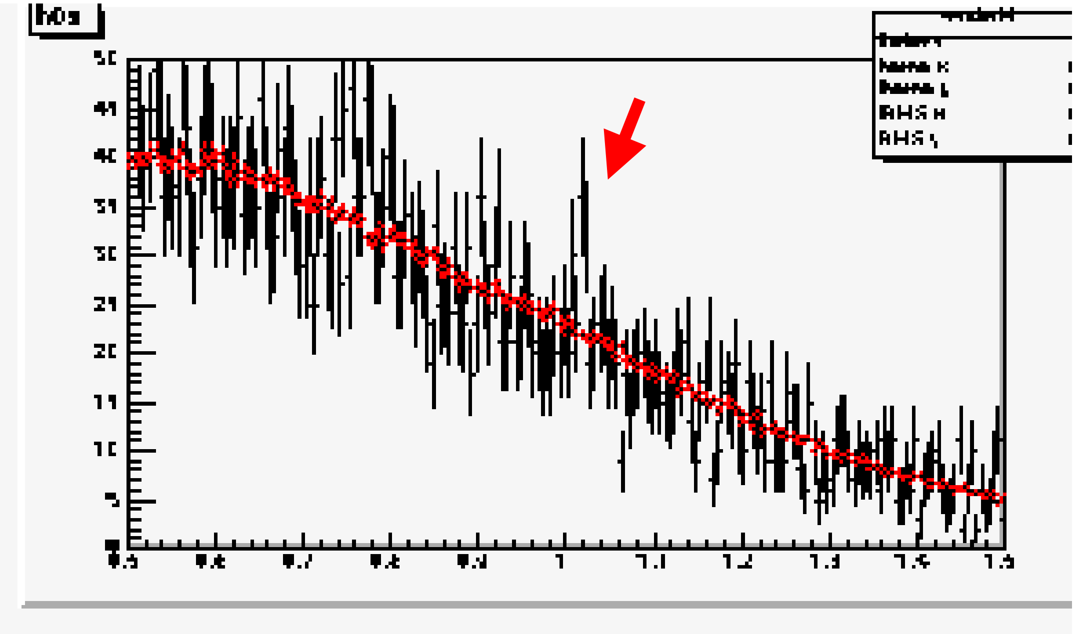
- $3\sigma_{mb}$: N=60 bkg=342
- $2\sigma_{mb}$: N=58 bkg=238
- $4\sigma_{mb}$: N=55 bkg=414

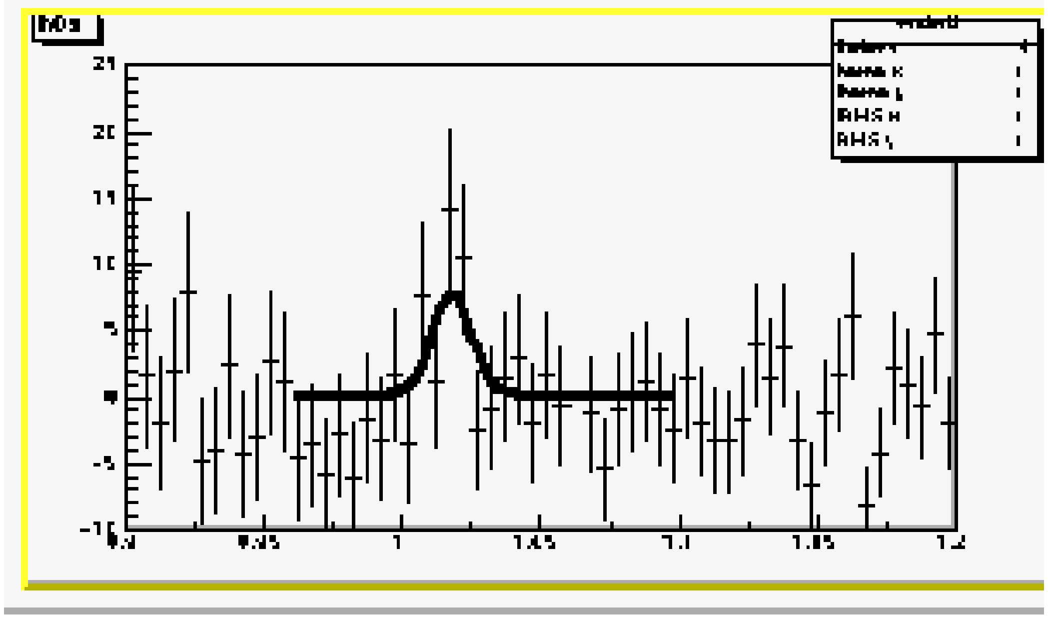




(pt2) $M_T - m_0 = 0.25-0.75$

- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.006 ± 0.002 (at limit)
  - Limitted at 1 sigma below min bias
- χ^2/DOF=31/13
- 3σ: N=29 bkg=272
- 2σ: N=26 bkg=181
- 4σ: N=27 bkg=336

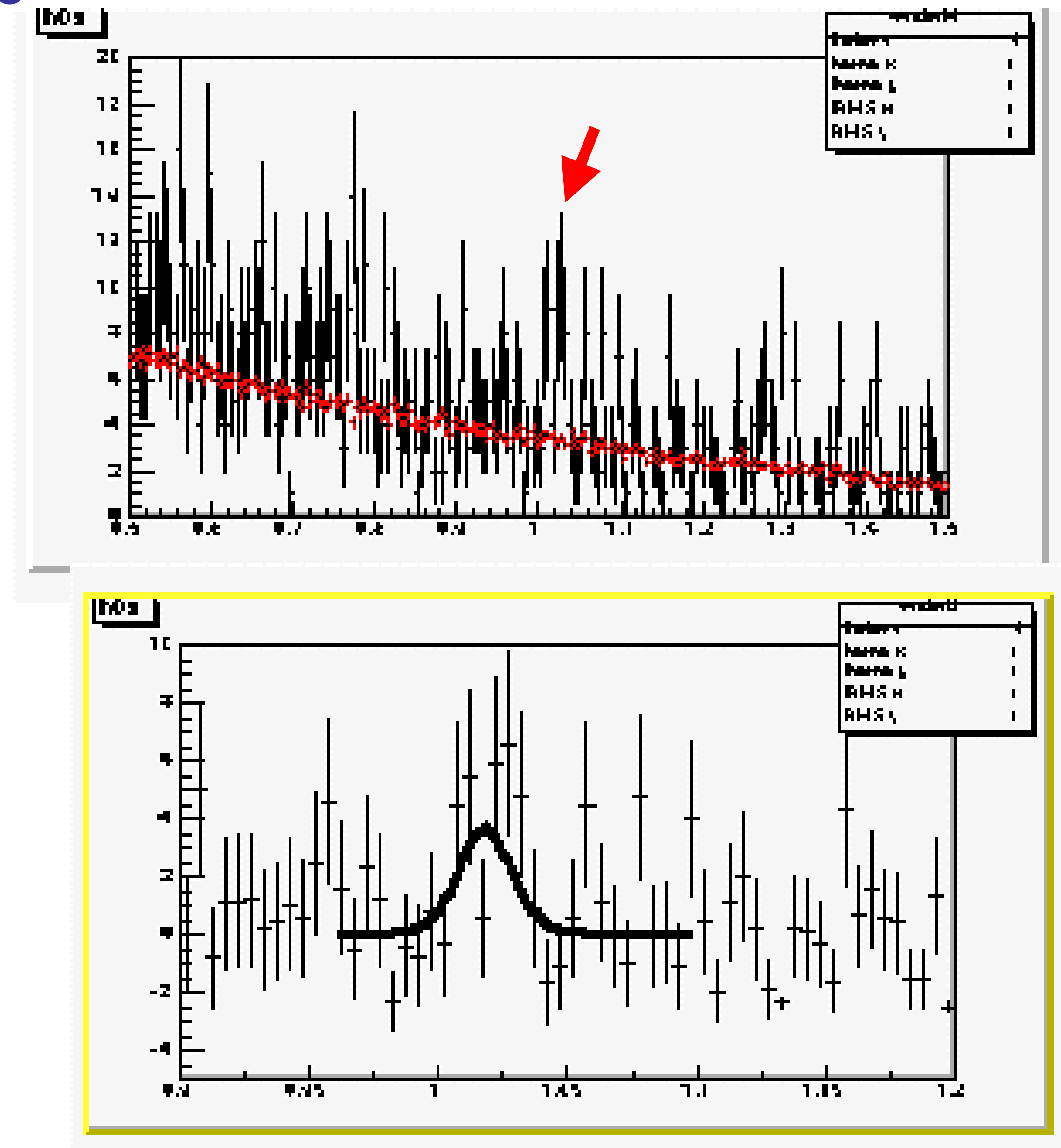




(pt3) $M_T - m_0 = 0.75\text{-}1.25$

- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- $\sigma = 0.0092 \pm 0.0026$
- χ^2/DOF=28/13
- 3σ: N=27 bkg=64
- 2σ: N=27 bkg=51
- 4σ: N=26 bkg=73

- Assuming σ=0.0092
  - 3σ: N=27 bkg=64
  - 2σ: N=29 bkg=59
  - 4σ: N=23 bkg=74

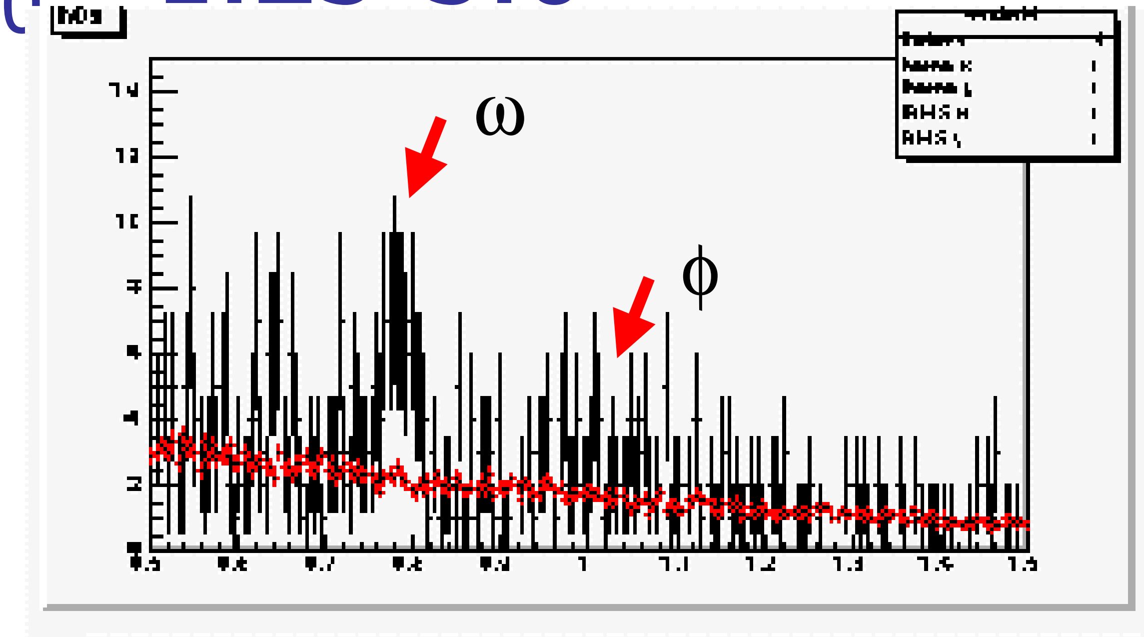


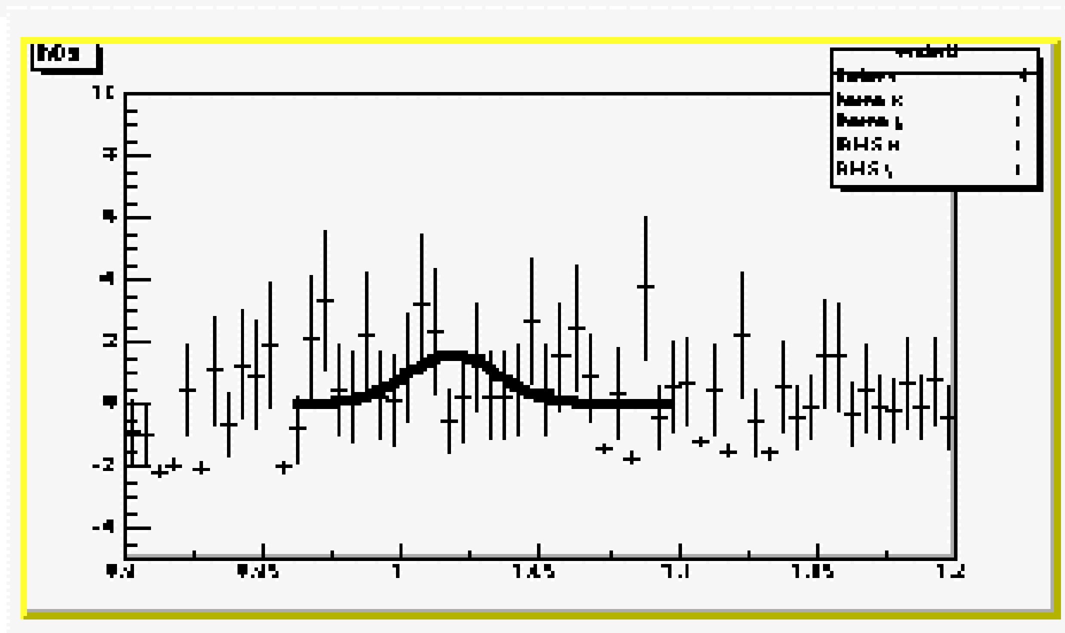
(pt4) $M_T - m_0 = 1.25\text{-}5.0$

- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.0299 ± 0.0093
- Fit fais

assume 15 MeV width
for the summing

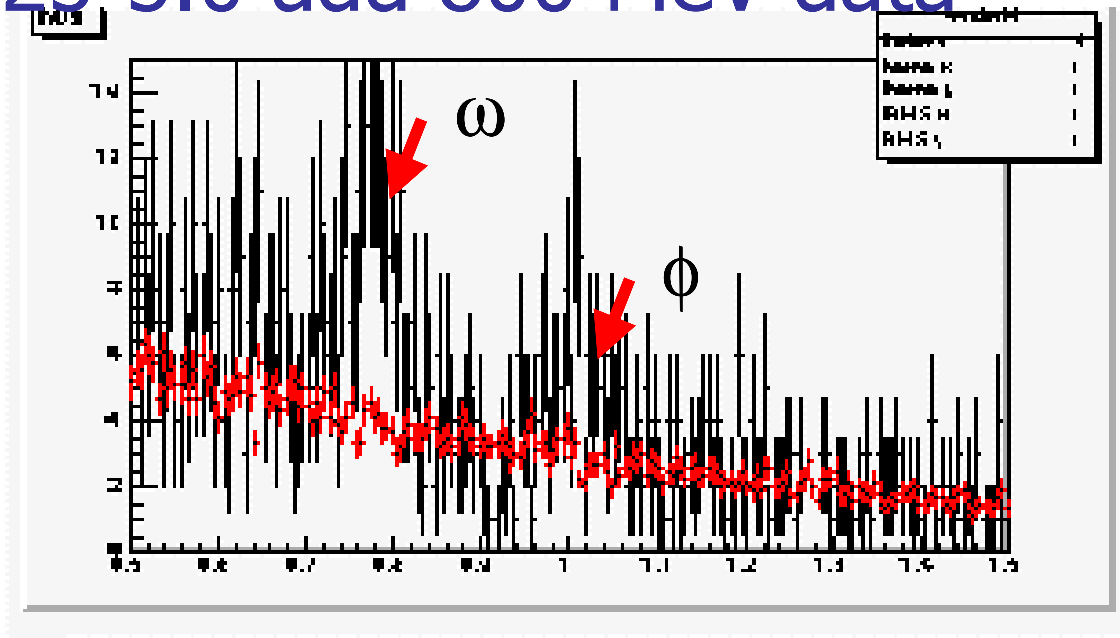
- 3σ: N=17 bkg=45
- 2σ: N=14 bkg=36
- 4σ: N=23 bkg=61

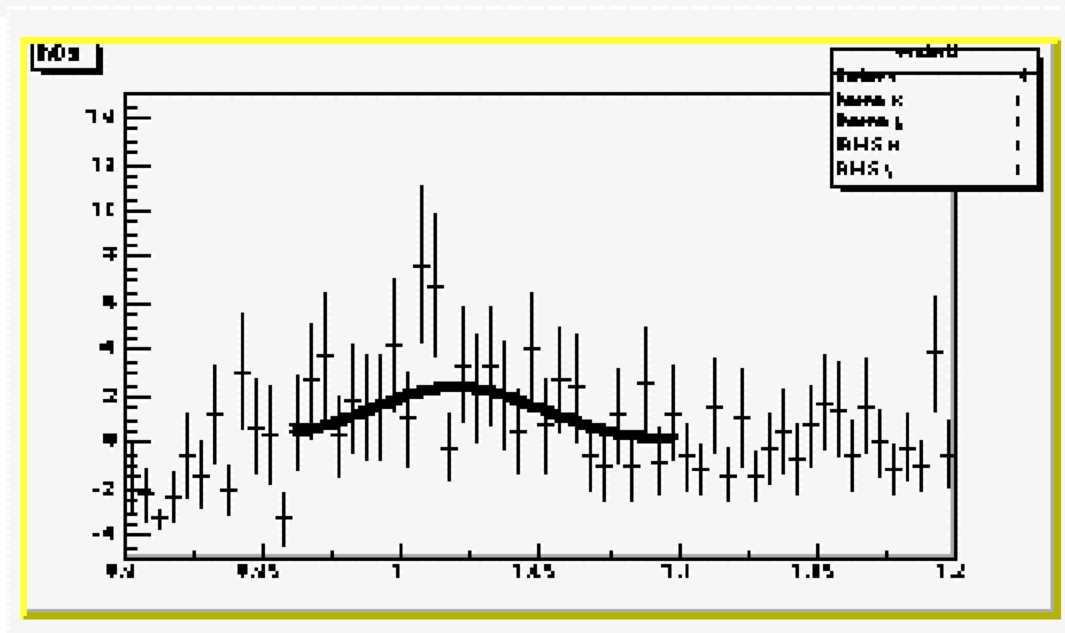




(pt4) $M_T - m_0 = 1.25\text{-}5.0$ add 800 MeV data

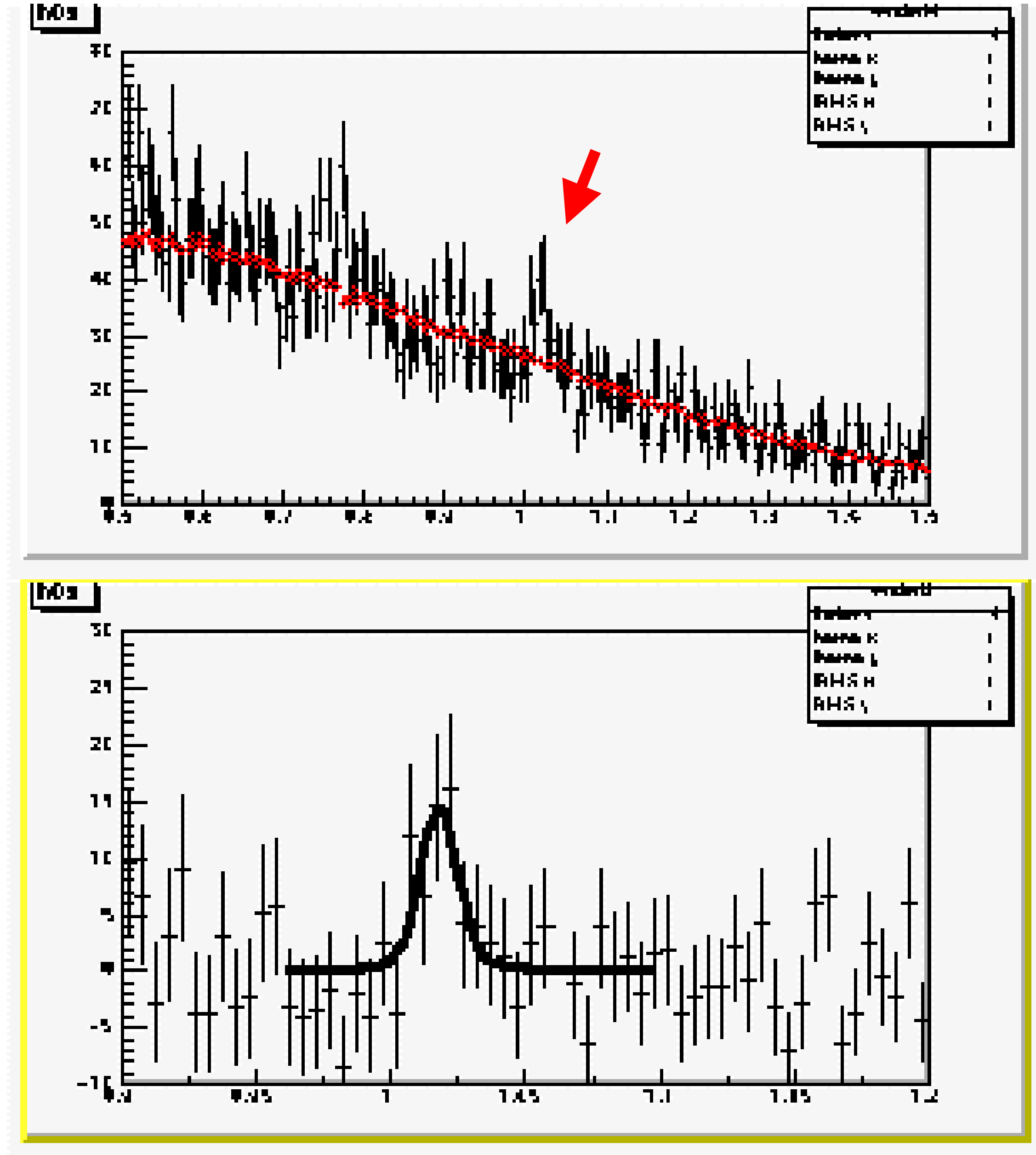
- Try adding 800 MeV
- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.0299 $\pm$ 0.0093
- Fit succeeds





(pt2a) $M_T - m_0 = 0.25\text{-}1.25$

- A special bin for use in a later comparison – give a more stable fit
- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- $\sigma=0.006 \pm 0.003$
- χ^2/DOF=24/13
- `3σ:  N=56 bkg=336`
- `2σ: N=54 bkg=232`
- `4σ: N=53 bkg=409`



The polynomial fit to the background

We also fit the invariant mass spectrum to the breit-wigner plus a 2nd degree polynomial background The following pages show these fits, together with the peak after subtracting off the background. This method, of course, does not work for a broad signal, (the sideband normalization does not either unless one makes sure that we are well away from the signal) but since we are measuring a peak, this gives us a good comparison to the sideband method we chose.

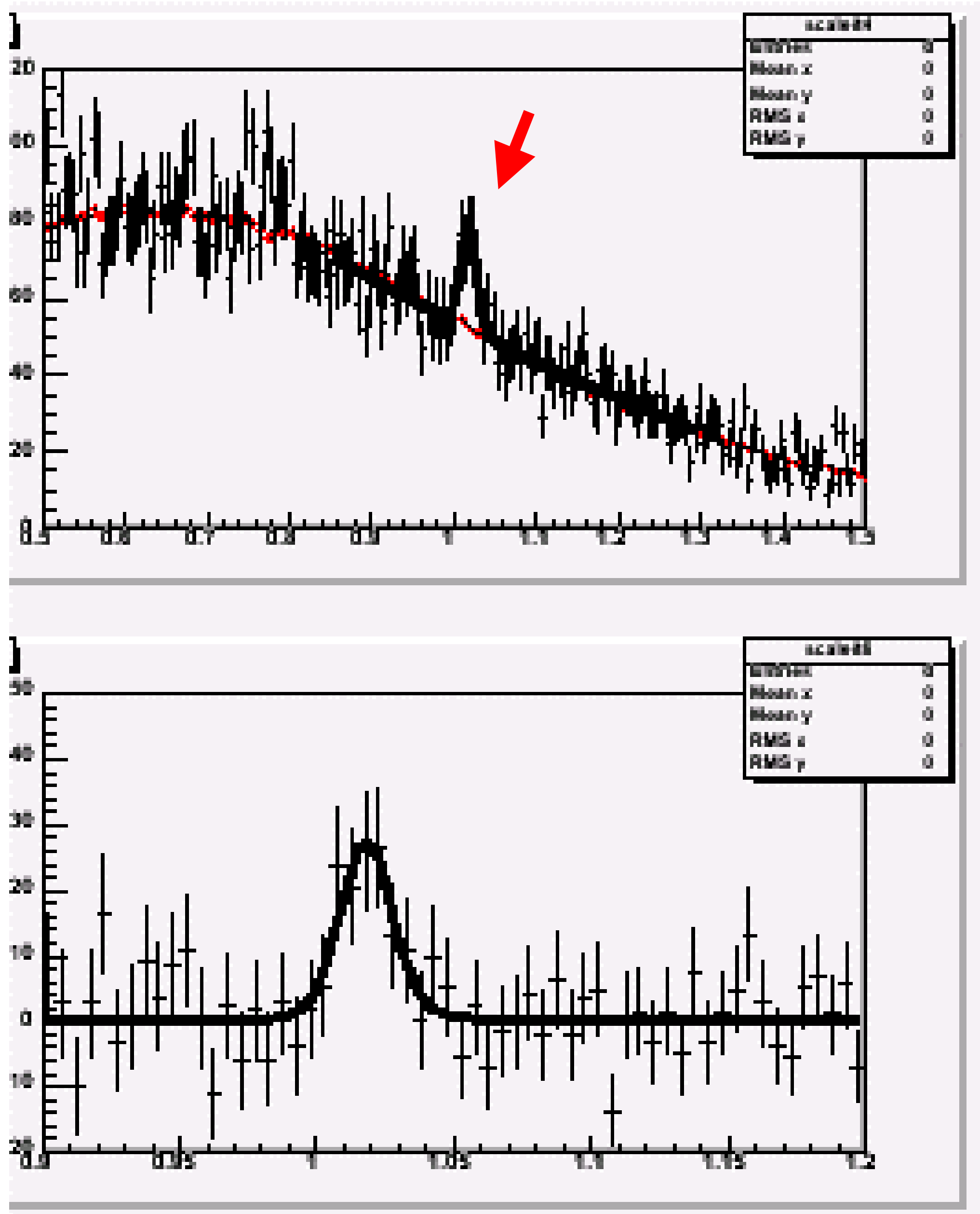
I note once again, that the fits done are only to obtain the sigma for the limits of integration and convince ourselves that we have a signal in each bin. The actual counts are done by integrating between two values of the invariant mass (I.e. $\pm$3 sigma) Again, we have chosen to use for these limits the mass and sigma for the min bias data. The three bins we are looking at have simillar sigma values – see table

The values are mass=1.0177, sigma=.0081

(polynomial bkg pt2) All mt

- M=1.0177 GeV
- Γ=0.00446 GeV (fixed)
- σ=0.0085 ± 0.0022
- χ^2/DOF=65/42
- 3σ: N=135
- 2σ: N=127
- 4σ: N=138

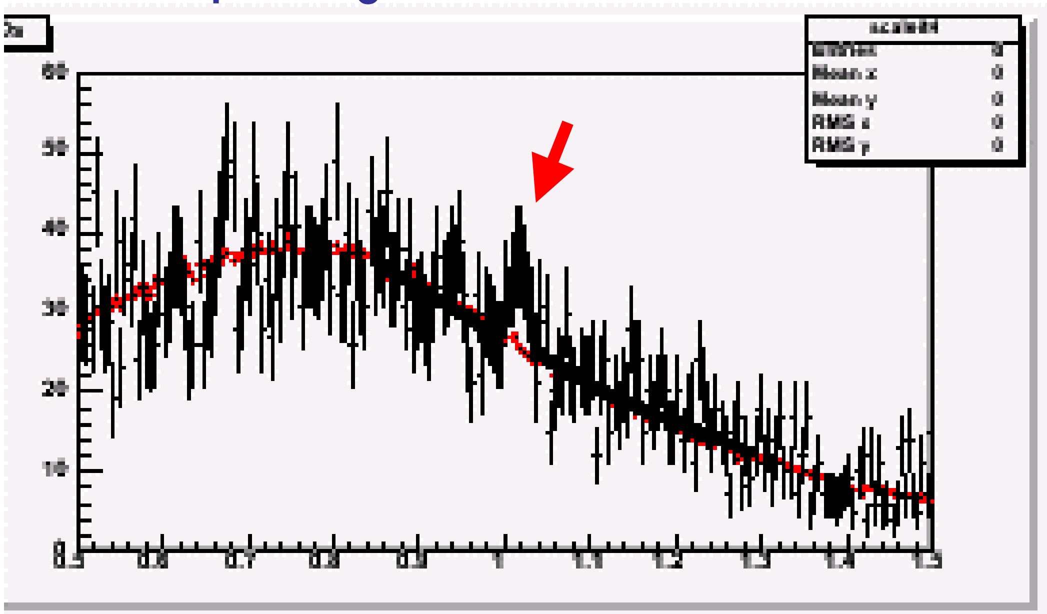
- The mixed bkg is in red and the bw+polynomial bkg is in black

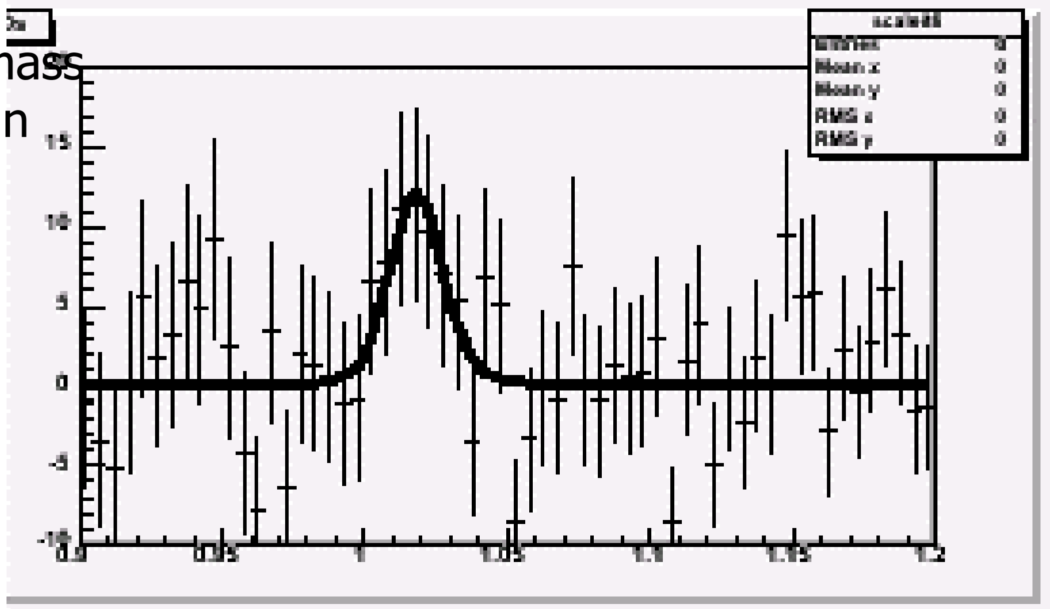


(polynomial bkg pt2) M_T -m_0 =0-0.25

- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.0083 $\pm$ 0.0031
- χ^2/DOF=72//42
- 3σ: N=60
- 2σ: N=59
- 4σ: N=57

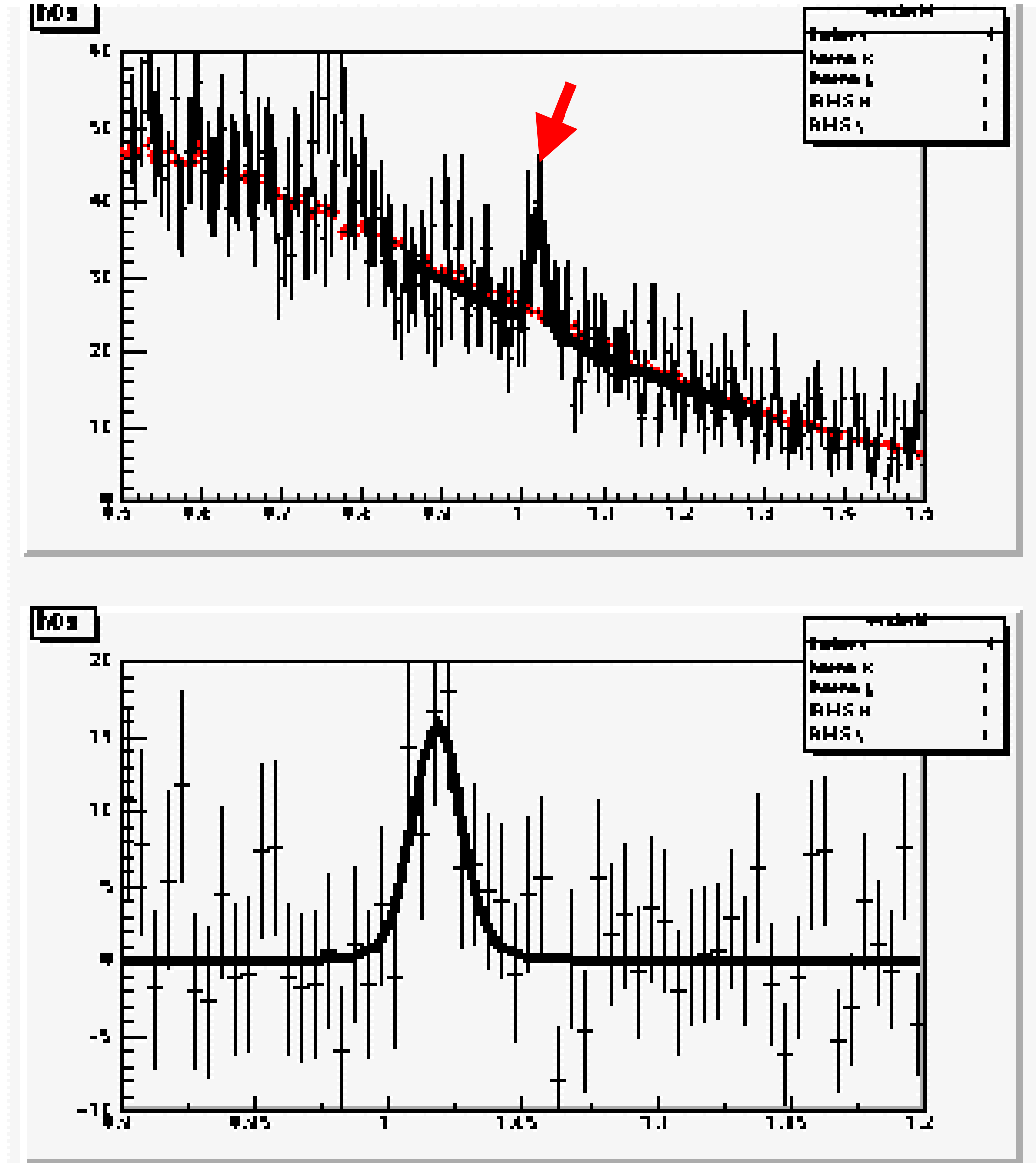
- In the separate mt bins, the mass is held to the value seen in min bias





(polynomial bkg pt2) $M_T - m_0 = 0.25\text{-}1.25$

- A special wider bin for a stable fit
- M=1.0177 GeV (fixed)
- Γ=0.00446 GeV (fixed)
- σ=0.008 $\pm$0.003
- χ^2/DOF=70/42
- 3σ: N=80
- 2σ: N=69
- 4σ: N=80



Yields

In Each bin of mt we calculate a yield using the following:

$$\frac{dN}{dydm_T} = \frac{N_{rec}}{N_{MB\ \text{sampled by ERT}}} \frac{1}{\Delta y \Delta m_T} \frac{1}{BR} \frac{1}{\varepsilon_{trigger}} \frac{1}{\varepsilon^2_{PID} Acc} \frac{1}{\varepsilon_{run-by-run}} \frac{1}{\varepsilon_{other}}$$

$$Where$$

$$\varepsilon_{other} = \varepsilon_{embed}$$

N_{rec} are is the number of phi's extracted for each bin of Mt. Δy is the rapidity interval over which the yield is calculated. In practice this is the interval over which the MC is thrown, which in our case is 1.2 since the MC is thrown in a range $|y|<0.6$. Δmt is the mt bin, and BR is the branching ratio. $\varepsilon_{Trigger}$ is the trigger efficiency which we will need to calculate. The factor ε^2_{PID}Acc is the acceptance including the particle identification efficiency. These two factors will be obtained using the Monte Calro. The embedding efficiency is assumed to be 1 since the correction for peripheral events in AuAu with a higher mean multiplicity also had an embedding efficiency of 1.

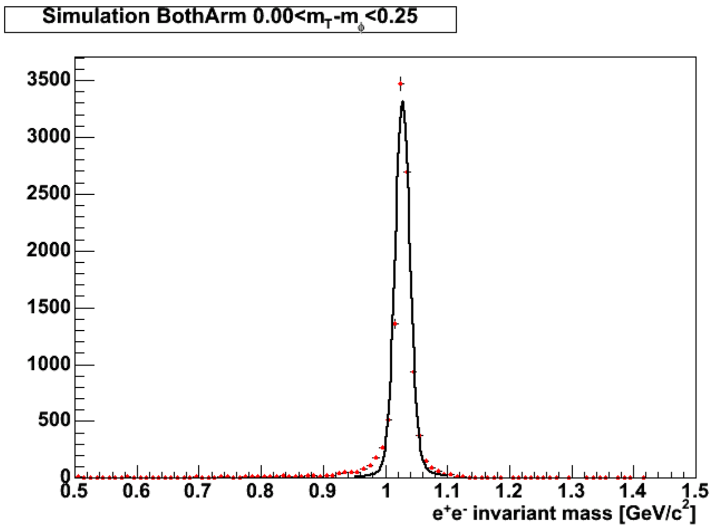
Simulations

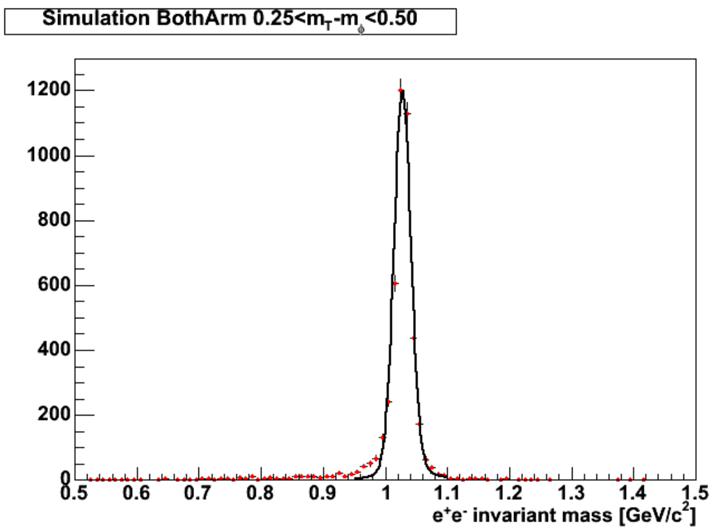
We now wish to find the acceptances and trigger efficiencies using the standard PISA-reconstruction-DST chain. The plan was to start with Weitzman generated PISA files from run-2 (~3M in 200 files). These would be run through the detector simulations and reconstruction. It was necessary to convert the files to the new Fun4all format. We were lucky enough to have Indrani on our team so this was done rather quickly. On Jan 2 the dst production succeeded and we were able to obtain acceptances and trigger efficiencies. Prior to Jan 2, a simple exodus based acceptance and trigger efficiency was used which utilized particle ID efficiencies from Sasha Lebedev. In general, the exodus based MC overestimated the acceptance and trigger efficiency, presumably because of dead channels, and holes in the detector. A comparison will be made between the PISA and the simple MC.

The MC

- The files pisa hits files made by dipali are described in the analysis note for phi to ee in run-2 [see phi to ee run-e analysis note]. 3M Phi's are thrown
  - Flat in rapidity with |y|<0.6
  - Uniform in azimuth $0<\phi<2\pi$
  - Flat vertex position |z|<30cm
  - $dN/dp_T=p_T \exp(-m_T/T_0)$ with T_0=320 MeV ($T_0=t_{fo}+\beta^2 m$, where t_{fo}=157, and β=0.4)
- Pisa hits files were then generated which had to be converted to Fun4all format
- The data was reconstructed
- uDST's and nDST's were made
- These were then processed in an identical manner as the data to get the acceptance
- The pisa hits files were from run-2. The recostruction field map was from run-3 which had a stronger field by about 1%. The mass of the phi reconstruced about 1% high at about 1027. Widths were generally followed the same trend as the data, that is, at higher mt, the widths were wider.

detected mass spectra in simulation

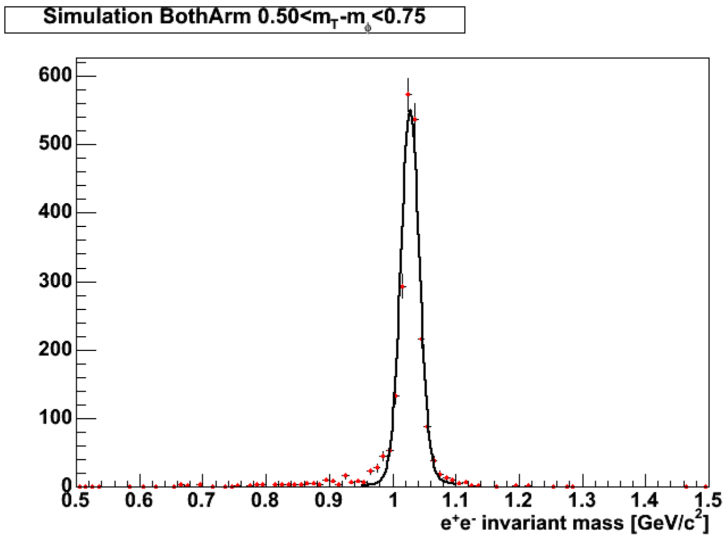


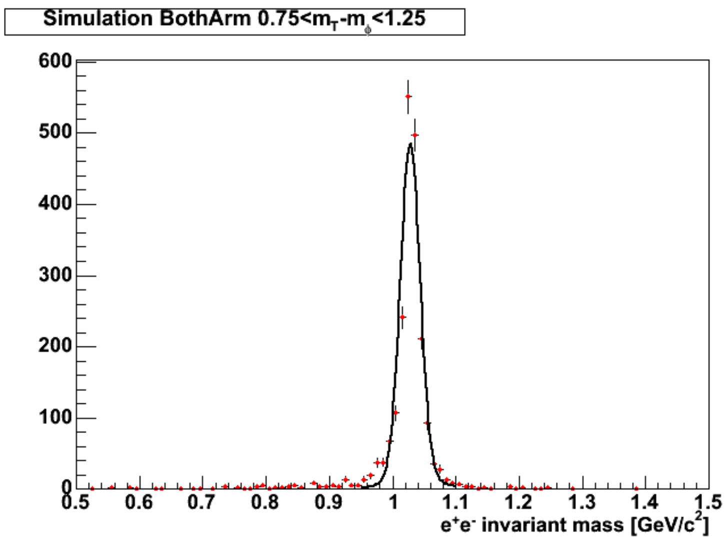


- $0 < m_T < 0.25$
- mass = 1027.44 +- 0.14 MeV
- sigma = 10.91 +- 0.15 MeV
- acceptance
  - 6511/973457 = 0.67% (1σ)
  - 8709/973457 = 0.89% (2σ)
  - 9536/973457 = 0.98% (3σ)

- $0.25 < m_T < 0.5$
- mass = 1027.27 +- 0.24 MeV
- sigma = 12.60 +- 0.25 MeV
- acceptance
  - 2671/544577 = 0.49% (1σ)
  - 3647/544577 = 0.67% (2σ)
  - 3965/544577 = 0.72% (3σ)

detected mass spectra in simulation

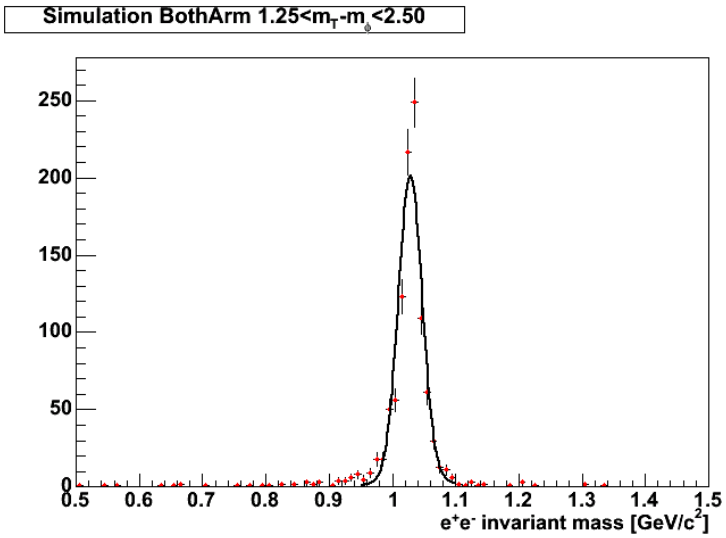


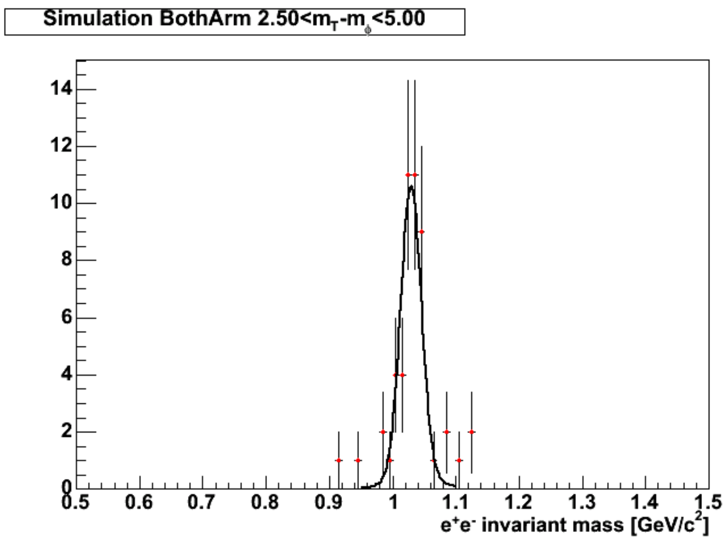


- $0.5 < m_T < 0.75$
- mass = 1027.34 +- 0.37 MeV
- sigma = 13.58 +- 0.41 MeV
- acceptance
  - 1355 / 294628 = 0.46% (1σ)
  - 1798 / 294628 = 0.60% (2σ)
  - 1945 / 294628 = 0.65% (3σ)

- $0.75 < m_T < 1.25$
- mass = 1027.44 +- 0.41 MeV
- sigma = 14.64 +- 0.47 MeV
- acceptance
  - 1305 / 236409 = 0.49% (1σ)
  - 1693 / 236409 = 0.67% (2σ)
  - 1839 / 236409 = 0.72% (3σ)

detected mass spectra in simulation





- $1.25 < m_T < 2.5$
- mass = 1027.68 +- 0.67 MeV
- sigma = 17.92 +- 0.66 MeV
- Acceptance
  - 664 / 80544 = 0.82% (1σ)
  - 870 / 80544 = 1.06% (2σ)
  - 973 / 80544 = 1.14% (3σ)

- $2.5 < m_T < 5$
- mass = 1028.67 +- 2.63 MeV
- sigma = 15.43 +- 3.01 MeV
- Acceptance
  - 29 / 2478 = 1.14% (1σ)
  - 40 / 2478 = 1.17% (2σ)
  - 42 / 2478 = 1.63% (3σ)

Comparison of widths

	data	Mc
0-.25	.0084±.0032	.011±.0002
.25-.5	Hits .006 limit	.013±.0003
.5-.75		.014±.0004
.75-1.25	.0093±.0026	.015±.0005
1.25-2.5	.029 ±.010 with 800 MeVdata	.018±.0007
2.5-5		.015±.003
Total	.0081±.0021	

Combination bins/Overall acc

- .25-.75
  - $0.25 < m_T < 0.5$
    - acceptance
    - 2671/544577 = 0.49% (1σ)
    - 3647/544577 = 0.67% (2σ)
    - 3965/544577 = 0.72% (3σ)
  - $0.5 < m_T < 0.75$
    - acceptance
    - 1355 / 294628 = 0.46% (1σ)
    - 1798 / 294628 = 0.60% (2σ)
    - 1945 / 294628 = 0.65% (3σ)
- (3965+1945)/(544577+294628)

  ACC=**0.704 %** (3σ)

- 1.25-5.00
  - $1.25 < m_T < 2.5$
    - Acceptance
    - 664 / 80544 = 0.82% (1σ)
    - 870 / 80544 = 1.06% (2σ)
    - 973 / 80544 = 1.14% (3σ)
  - $2.5 < m_T < 5$
    - Acceptance
    - 29 / 2478 = 1.14% (1σ)
    - 40 / 2478 = 1.17% (2σ)
    - 42 / 2478 = 1.63% (3σ)
- (973+42)/(80544+2678)

  ACC=**1.22%** (3σ)

Total Overall Acceptance

- Delta y=1.2
  - 9536/973457 = 0.98% (3σ)
  - 3965/544577 = 0.72% (3σ)
  - 1945 / 294628 = 0.65% (3σ)
  - 1839 / 236409 = 0.72% (3σ)
  - 973 / 80544 = 1.14% (3σ)
  - 42 / 2478 = 1.63% (3σ)

- Overall acceptance
- → 18300/2132093**=.858% (3σ)**

- Delta y=1
  - 2132093*.5/.6=1776690
  - 18300/1776690=**1.03% (3σ)**
  - compare with weitzman CF
  - 1/206=.49% (harsher cuts on electron)

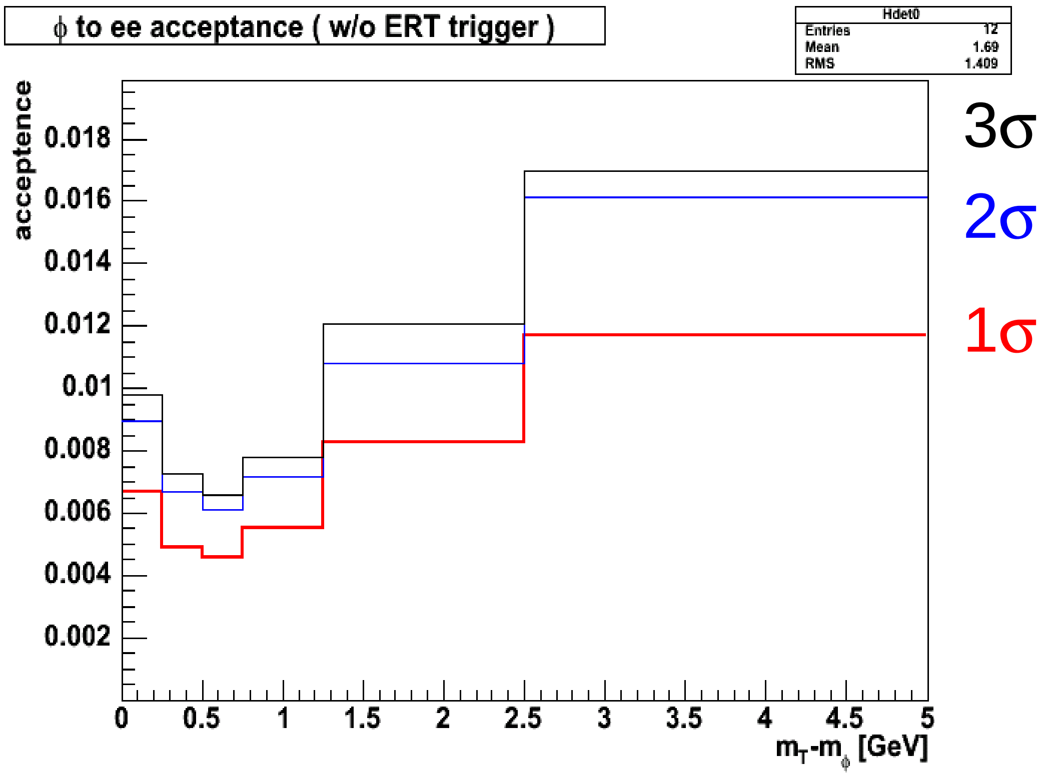
Yet another big bin

- .25-1.25
  - $0.25 < m_T < 0.5$
    - acceptance
    - 2671/544577 = 0.49% (1σ)
    - 3647/544577 = 0.67% (2σ)
    - 3965/544577 = 0.72% (3σ)
  - $0.5 < m_T < 0.75$
    - acceptance
    - 1355 / 294628 = 0.46% (1σ)
    - 1798 / 294628 = 0.60% (2σ)
    - 1945 / 294628 = 0.65% (3σ)
  - $0.75 < m_T < 1.25$
  - acceptance
    - 1305 / 236409 = 0.49% (1σ)
    - 1693 / 236409 = 0.67% (2σ)
    - 1839 / 236409 = 0.72% (3σ)
- (3965+1945+1838)/(544577+294628 +236409)

  ACC=**0.695 %** (3σ)

- Ert eff for .25-1.25
  - .501 +- .006

Acceptance

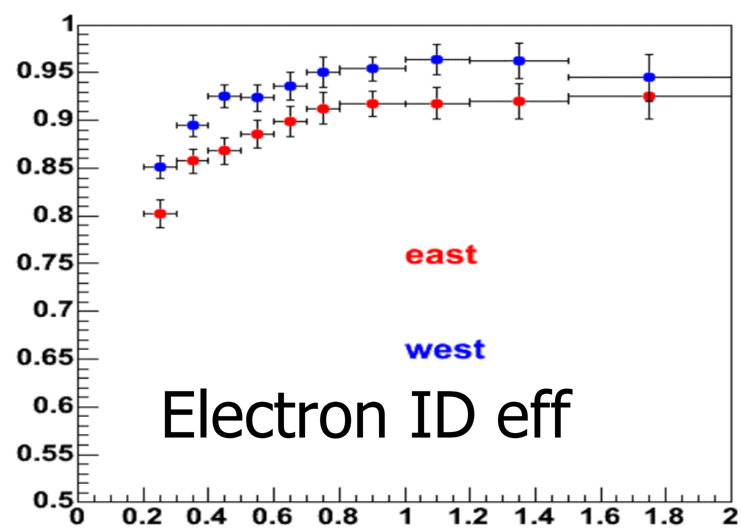


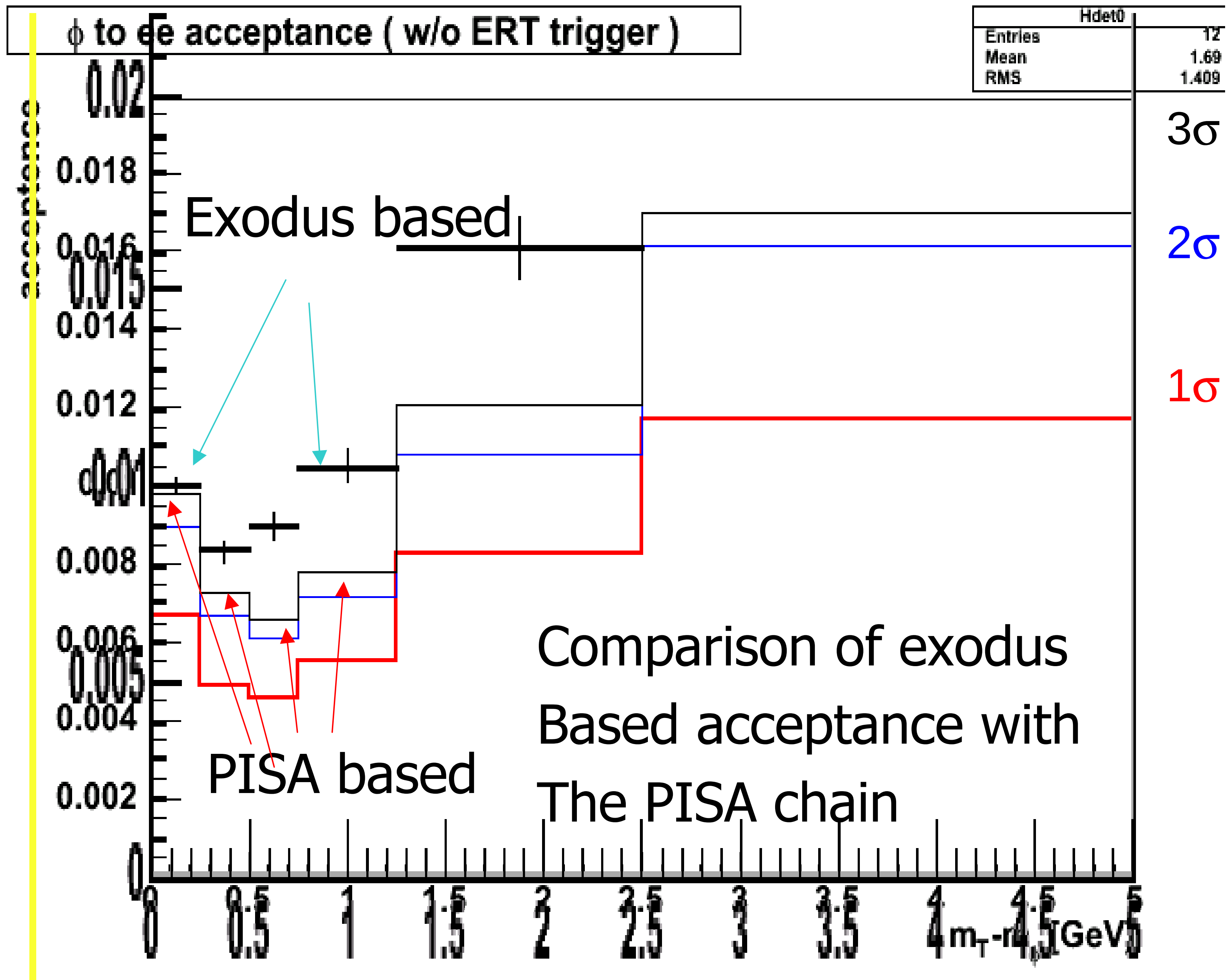
- Acceptance
  - Same eID and pair cut as the data
  - Number of sigma indicate mass window of integration.

Exodus based simulations

Originally exodus based simulations were used to understand geometric acceptances and efficiency due to triggering and analysis cuts. The strategy used was to use exodus to obtain the geometric acceptance. This was used in conjunction with measured electron identification efficiency provided by Sasha Lebedev which used conversion electrons to measure this. The cuts used in our analysis match those of the measurement This information is taken as input to the exodus simulation. As one can see on the next page, the

Exodus based simulations overestimated the acceptance. This lead to an increase in the observed cross section from the initial analysis note. This was presumably because of dead regions in the detector, however this will need to be investigated.



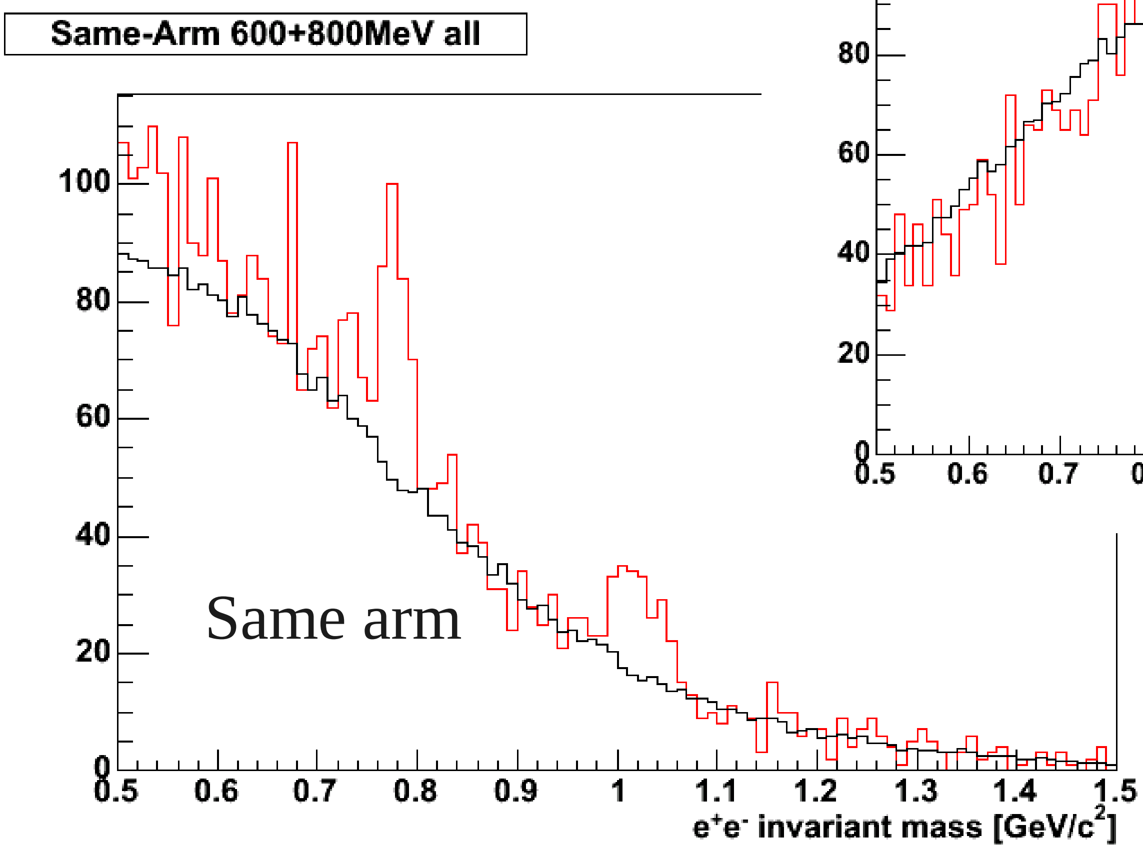


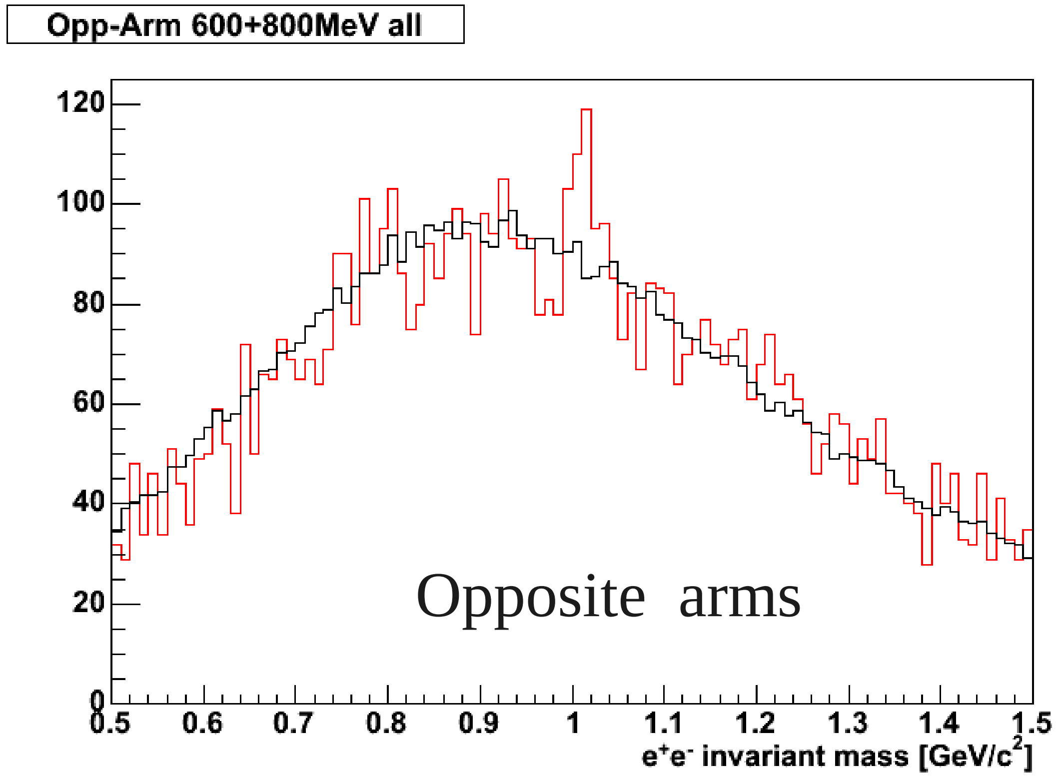
ϕ to ee acceptance (w/o ERT trigger)
Hdet0
Entries 12
Mean 1.69
RMS 1.409
acceptance
Exodus based
PISA based
3σ
2σ
1σ
Comparison of exodus
Based acceptance with
The PISA chain
m_T-m_ϕ [GeV]

Some general characteristics of the acceptance

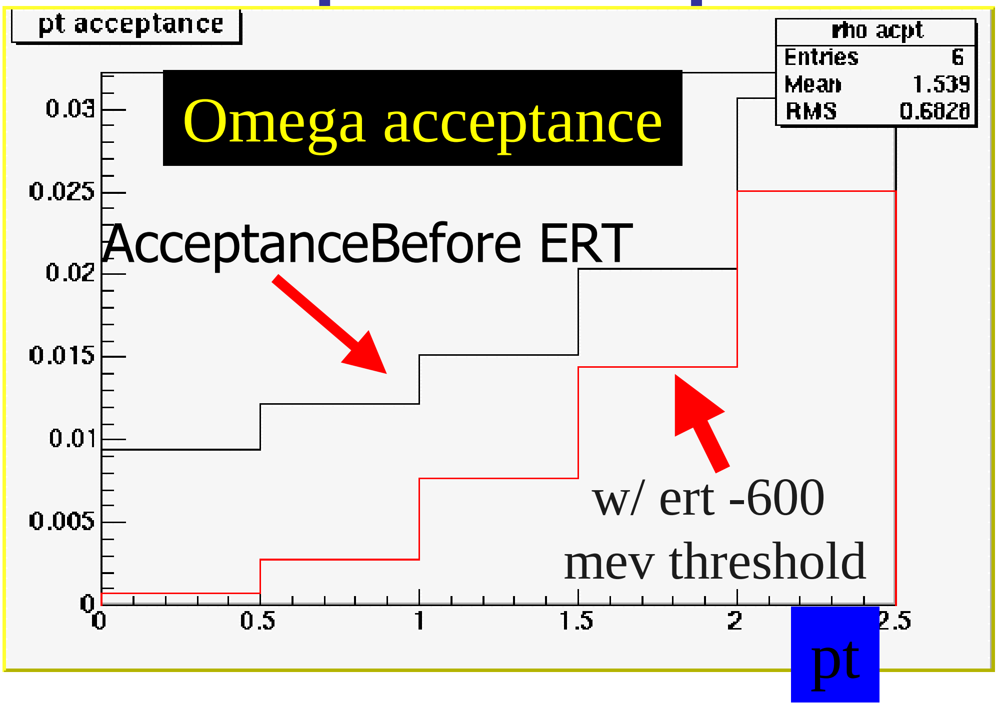
There were some questions about the acceptance of the phi and whether it is more likely to be in opposite arms. In fact about 60% of the phi mesons go into the same arm because of the ert trigger. Requiring the ert trigger means that one of the electrons must have over 600 MeV. The trigger has a turn on and does not come into its full efficiency until about 2 GeV. Assuming a low pt phi, requiring a one of the electrons fire the trigger would presumably put the other electron in the other arm. However, PHENIX does not measure very low momentum particles (<100-200 MeV). This in turn means that one favors a rather high pt phi which then will put both electrons in one arm Shown on the next page is the phi signal in the same and opposite arms. Both configurations have a reasonable signal.

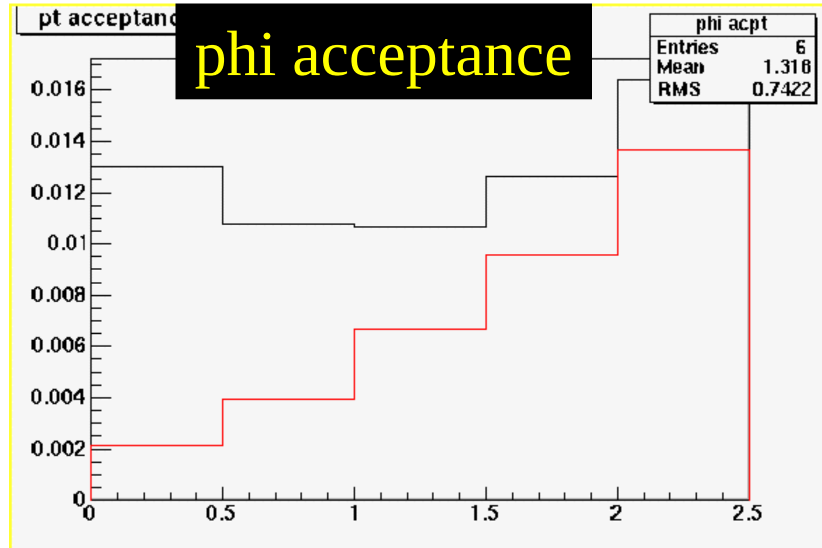
Phi to ee, same and opposite arms

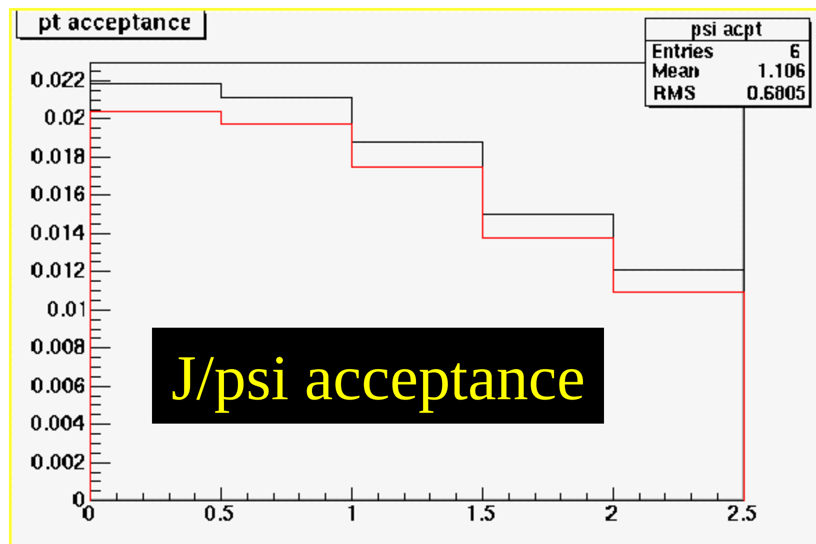




Ert: pt acceptance





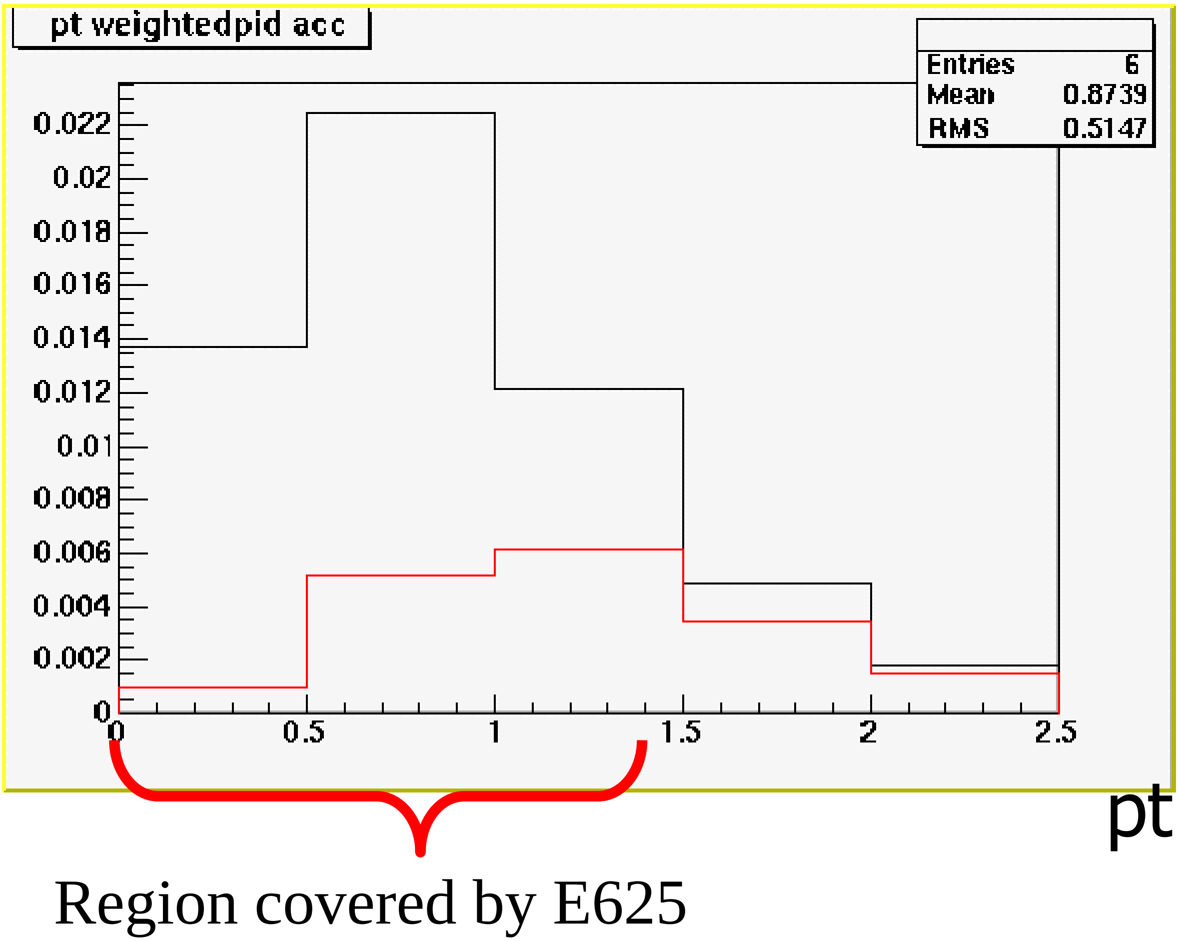


Let us stop and consider the effect of the ERT trigger on the acceptance. It hurts low pt acceptance for omega/phi

- Little effect on J/psi

Accepted pt distribution

- It is instructive to fold in the exponentially falling input spectrum together with the complete acceptance. The ERT trigger will suppress the low momentum component as well. Hence a maximum in the number of accepted phis' should occur at a pt ~1.3 GeV. This corresponds to an mt~ Note that pt~1 GeV corresponds to an mt-m ~0.7

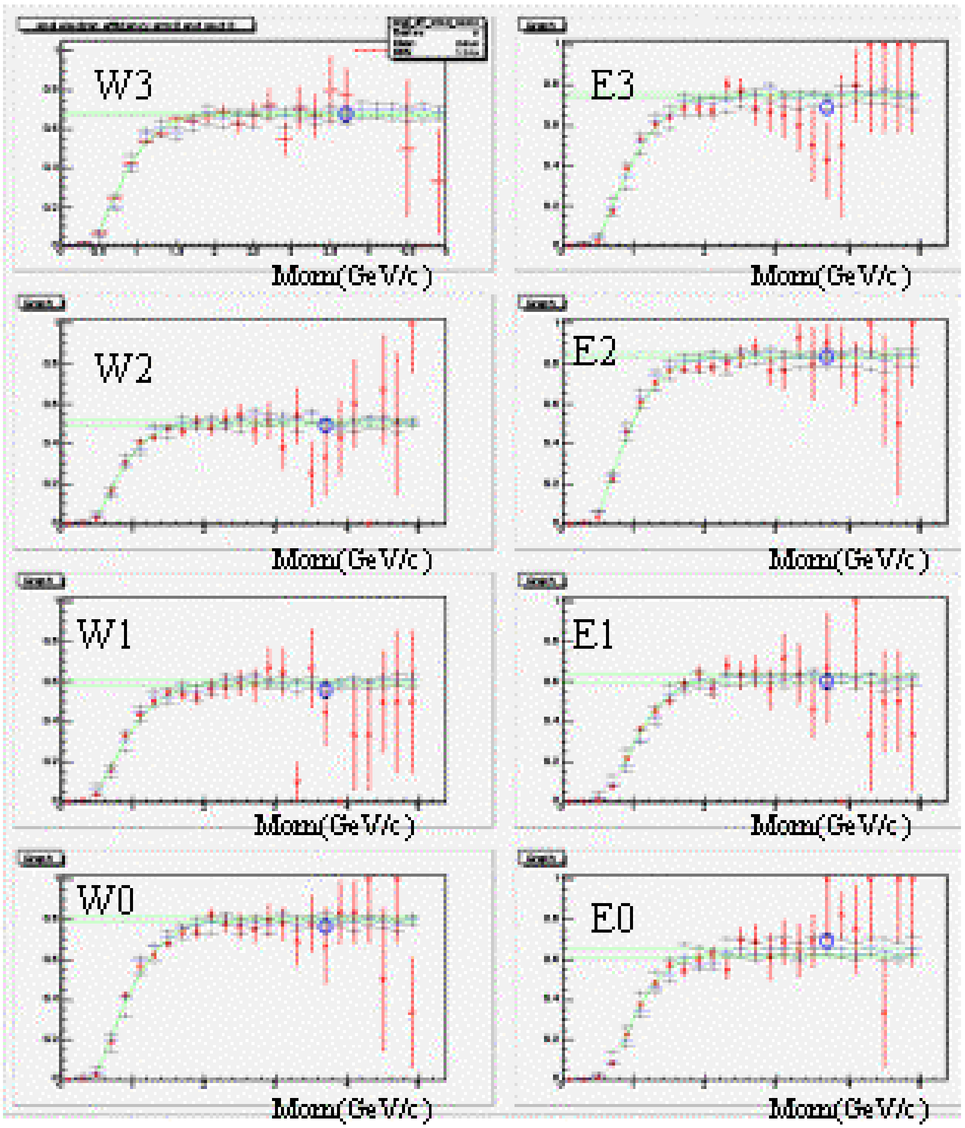


Trigger efficiencies

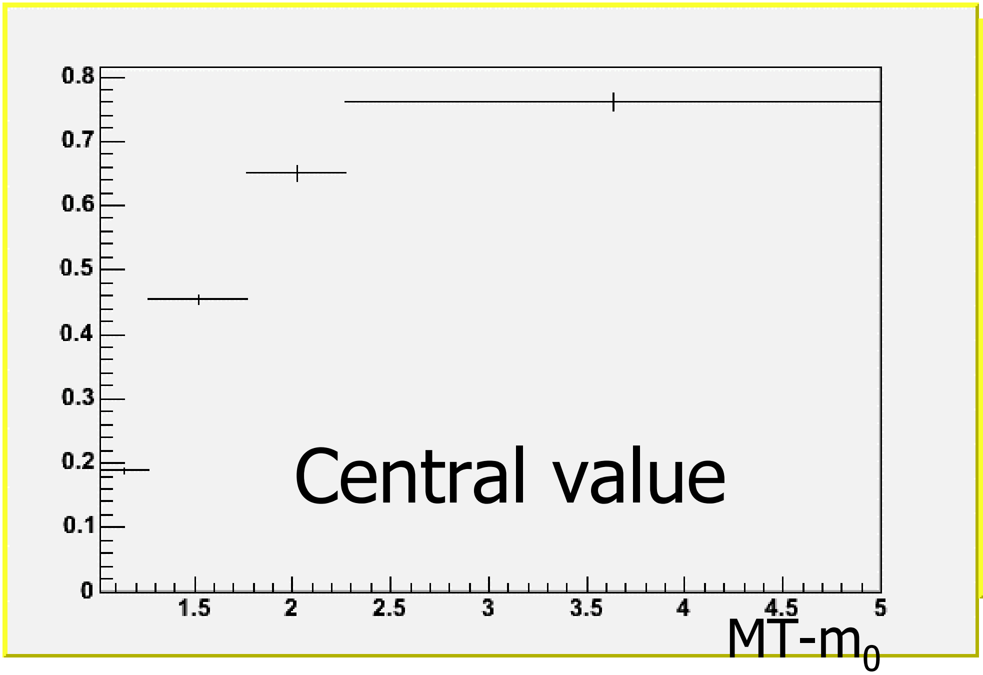
- The next step is to obtain the trigger efficiencies. Wei has a simulation which uses a input MC mDST, in our case of phi to ee. He then simulates the trigger to obtain a trigger efficiency. In order to obtain a systematic error, the noise and the thresholds are varied and a upper and lower value for the trigger efficiency is obtained. As soon as the mDST's were made available for the acceptance they were then used by wei to generate the trigger efficiency which is shown on the next page for the 600MeV threshold.

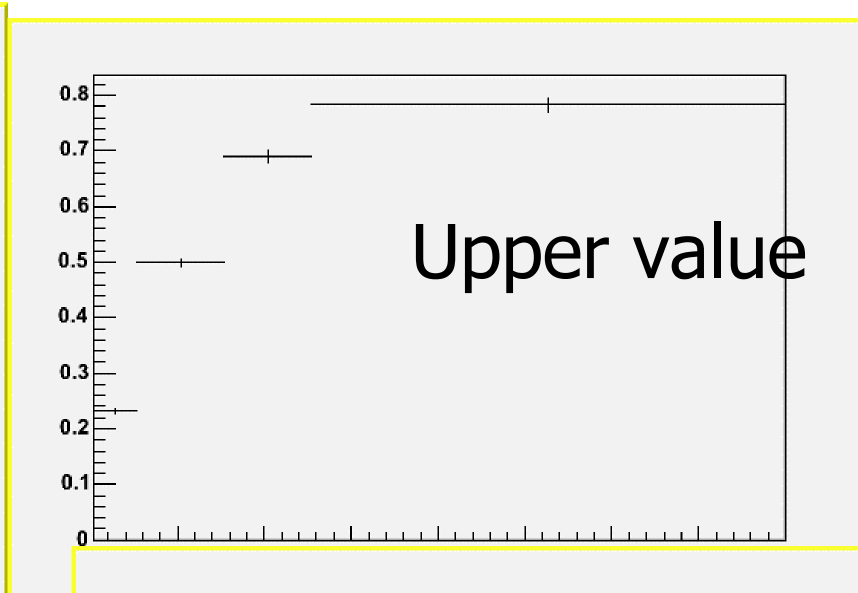
- For reference here are ERT efficiencies for the 8 sectors

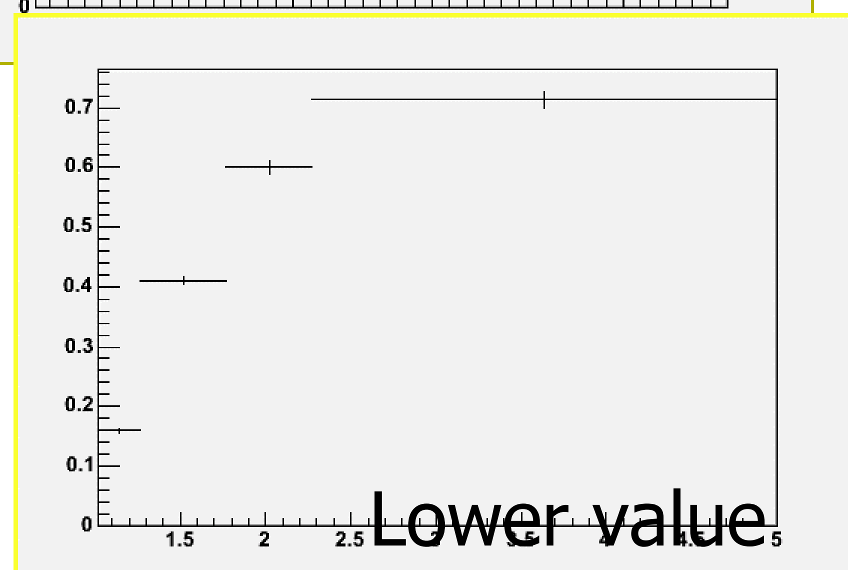
Eth=0.6GeV (RUN3 d-Au)



ERT trigger eff for phi to ee







- Overall trigger eff
  - Lower=0.326(.004)
  - Central=0.363(.004)
  - Upper=0.405(.004)

Put on single plot

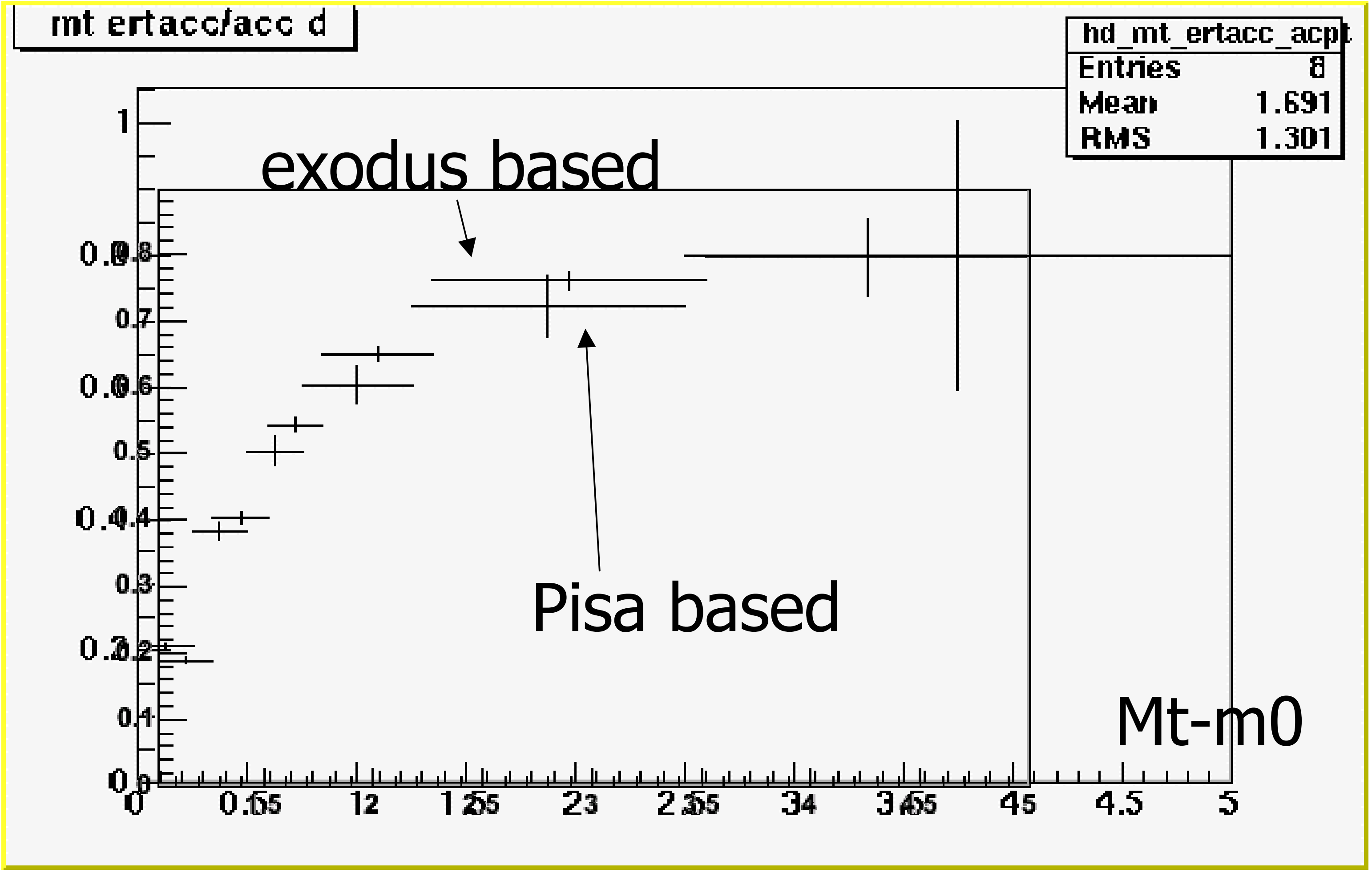
Table of ert efficiencies-600 MEV threshold

	Central value	Low value	High value
0-.25	189(.004)	.156(.004)	232(.005)
.25-.75	454(.007)	.410(.007)	.499(.007)
.75-1.25	.650(.011)	.600(.011)	.691(.011)
1.25-5	.762(.013)	.713(.014)	.783(.013)
Total	.363(.004)	.326(.004)	.405(.003)

Compare to exodus based

Originally a estimate of the trigger efficiency was done by using the electron turn on curves and combining them with exodus. Here is the comparison

(one is mt-m0, the other has mt as its x-axis) surprisingly the exodus based MC is not so bad.



Calculating the yield

We are now in a position to calculate the yield from the formula previously given. Note that a first calculation of the dN/dy can be done from just the total yield and the overall acceptance. We use as a standard set the 3 sigma mass window for the yield normalizing in the manner explained before.

That number is shown in the bottom line of the table and gives a yield of 0.06±.013(stat) from a simple total count and acceptance. The values at each of the mt bins are shown. The error shown is statistical only and is calculated as the sqrt of the total number of events in the mass window before the subtraction I.e. it is the sqrt(S+B)

Note that we show the 1.25-5 bin only for informational purposes. We will drop that bin. We then have only 3 bins left to fit.

mt-m	N	back	sqrt(b	ACC	trig	dy	dmt	br	dndydmt	error
0-0.25	60	342	18	0.0098	0.189	1.2	0.25	3.0E-04	1.92E-01	5.9E-02
0.25-0.75	29	272	16	0.0070	0.454	1.2	0.5	3.0E-04	2.70E-02	1.5E-02
0.75-1.25	27	64	8	0.0072	0.650	1.2	0.5	3.0E-04	1.71E-02	5.1E-03
1.25-5	17	45	7	0.0122	0.762	1.2	3.75	3.0E-04	7.23E-04	2.9E-04
TOTAL	126	706	27	0.0086	0.363	1.2	1	3.0E-04	5.97E-02	1.3E-02

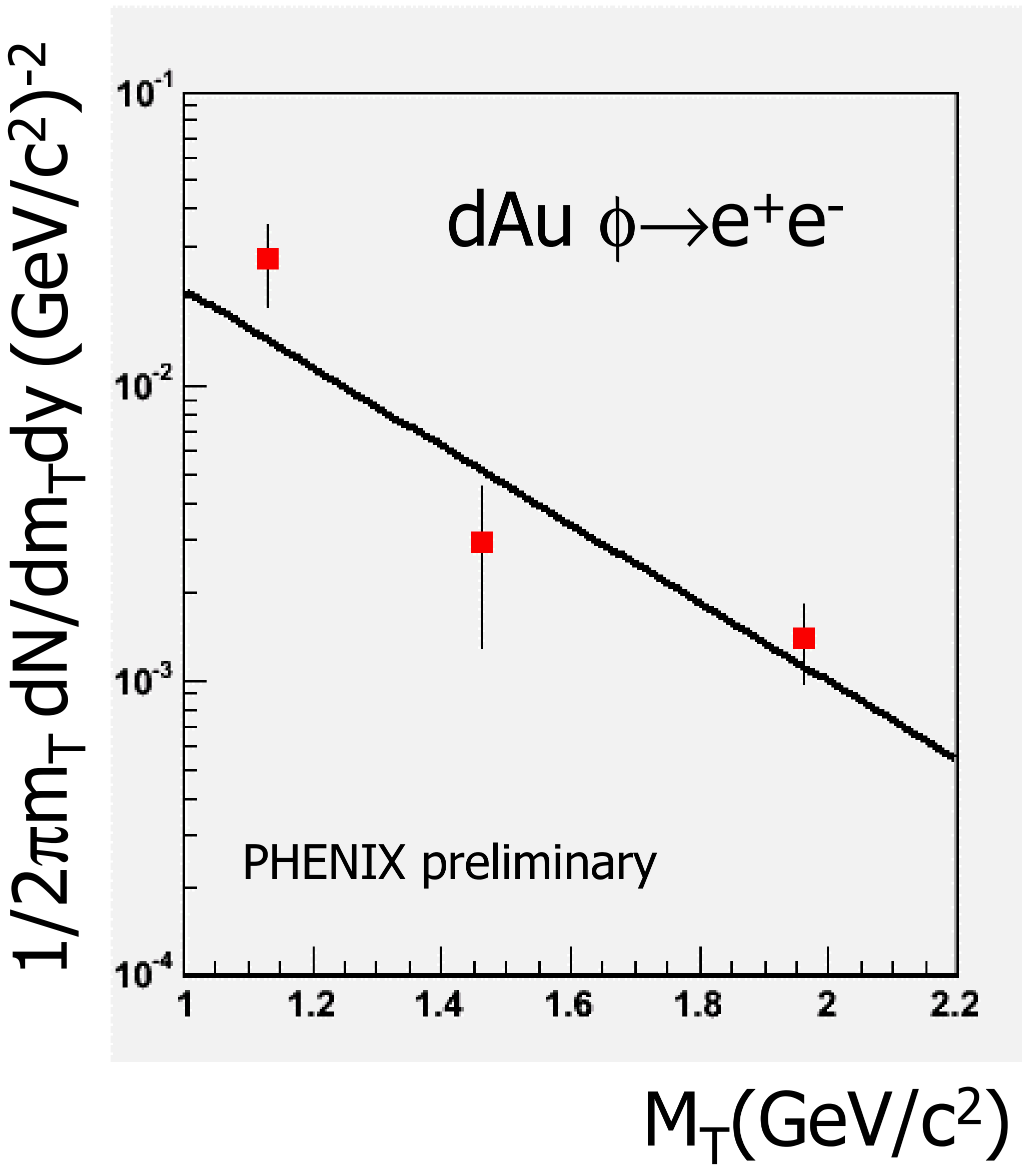
- Next the dN/dmt/dy points are fitted to an exponential as follows.

$$\frac{1}{2\pi m_T}\frac{d^2N}{dm_T dy} = \frac{dN/dy}{2\pi T(T+M_\phi)} e^{-(m_T - m_\phi)/T}$$

The centroid of each m_T bin was calculated iteratively by

$$< m_T >= \frac{\int m_T.exp(-m_T/T)}{\int exp(-m_T/T)}$$

dN/dm_T and yield



$dN/dy = .056 \pm .015$(stat) $\pm 50\%$(syst)

$T = 326 \pm 94$(stat) $\pm$ 53%(syst) MeV

(PHENIX preliminary)

- major contributions to the systematic error
  - normalization of the background and signal extraction and the way the variations affect T and hence dN/dy
  - run-by run variation from the Electron-RICH-Trigger

Systematic errors

- Several sources of systematic errors are considered. These we believe are the largest.
  - Changes in the acceptance because of the input spectrum given to the MC. I note that on face value the fit of T=326 MeV is self-consistent with the input value of T=320 MeV. We will vary the input spectrum to see the effect
  - Changes in the number of phi's counted. As mentioned, I will examine the effect of changing the background normalization scheme and the mass window chosen for integration
  - ERT efficiency. The systematic of the ERT trigger efficiency is obtained in a standard way used by the ERT group. The noise and thresholds are varied to obtain a upper and lower value for the ERT efficiency as shown previously. Note that the phi is very sensitive to the turn on of the ERT trigger.

Acceptance systematic error

- To get a handle on the systematic error on the acceptances due to the input inverse slope, I use the exodus based MC calculated with a variety of input slopes to make an estimate of this effect. Our standard value is 320 MeV and we will try two extremes at 250 and 440 MeV.

	320	250	440
0-.25	.0101	.0101	.0100
.25-.75	.0086	.0085	.0086
.75-1.25	.0105	.0105	.0106
1.25-5	.0167	.0154	.0189

We see that for the relatively narrow first three bins, this is ~1%. For the very wide bin this effect is ~20%. Since we do not use the last bin, we will use 1%.

systematic on the ERT eff due to the input slopes

- We do a similar exercise for the ERT efficiency, again using the exodus based calculation to get a handle on the effect

	320	250	440
0-.25	.206	.202	.209
.25-.75	.427	.419	.435
.75-1.25	.604	.599	.608
1.25-5	.728	.725	.741

Again the effect is very small although somewhat larger than for the acceptance in the lowest bin. It is about a 2% effect.

systematic on an overall calculation of the yield from the total number of phi's

- When we calculate the yield without using a dNdmt distribution, one essentially uses the input MC distribution to integrate to low mt. Hence the input MC distribution will make a much larger difference. This is ONLY for the case when one is not using the dN/dmt distribution. In this case it is a 25% effect.

	320	250	440
Acceptance (including ert)	.0043	.0036	.0056

Systematics from background subtraction and counting

- With an eye towards obtaining systematic error we compare the numbers we get from the various ways of counting. In the following 2 tables, the error is the sqrt(S+B) and delta is the percentage variation across the defend methods as compared to the "standard"
- The numbers should be consistent 1) across the methods(there are two tables) and 2) across the mass window of integration.
- The delta factors are just the difference between the method (or sigma) and the standard
- The error in several cases is as large as 45%
- This error can lead to error in the inverse slope of about 50%.
- When doing fits on those techniques that give 3 or more data point I get fluctations of ~ 20%

➔ Systematic error is dN/dy ~ 45%, in T~50%

Comparing

To a more standard side-band subtration method

And across "sigma"

		S+bkg	error	standard	sideband	delta for me
	0-.25	342	18	60	46	23%
3 sigma	.25-.75	272	16	29	41	41%
	.75-1.25	64	8	27	26	4%
	1.25-5	45	7	17	17	0%
	Total	706	27	126	123	2%
	0-.25	238	15	58	49	16%
2sigma	.25-.75	181	13	26	34	31%
	.75-1.25	59	8	27	27	0%
	1.25-5	36	6	14	14	0%
	Total	490	22	121	119	2%
	0-.25	443	21	55	38	45%
4sigma	.25-.75	354	19	27	37	31%
	.75-1.25	74	9	26	24	8%
	1.25-5	61	8	24	23	4%
	Total	818	29	124	120	3%
delta for	0-.25			8%		
3,4,5	.25-.75			10%		
sigma	.75-1.25			4%		
	1.25-5			11%		
	Total			2%		

Comparing to the polynomial background fit

		S+bkg	error	standard	ploynomial	delta for me
	0-.25	342	18	60	60	0%
3 sigma	.25-1.25	336	18	56	80	43%
	Total	706	27	126	135	7%
	0-.25	238	15	58	58	0%
2sigma	.25-1.25	240	15	54	69	28%
	Total	490	22	121	126	4%
	0-.25	443	21	57	57	0%
4sigma	.25-1.25	428	21	54	78	44%
	Total	818	29	130	138	6%

- In order to calculate the systematic difference to the polynomial fit a larger bin (.25-1.25) was used to stabalize the fit, and a comparison was made to the same bin in the standard fit. The number in the .25-1.25 bin is just the sum to within 1 of the .25-.75-1.25 bins.

Systematic error due to ert trigger eff

- Here we use the standard procedure developed by the ERT group as expained previously

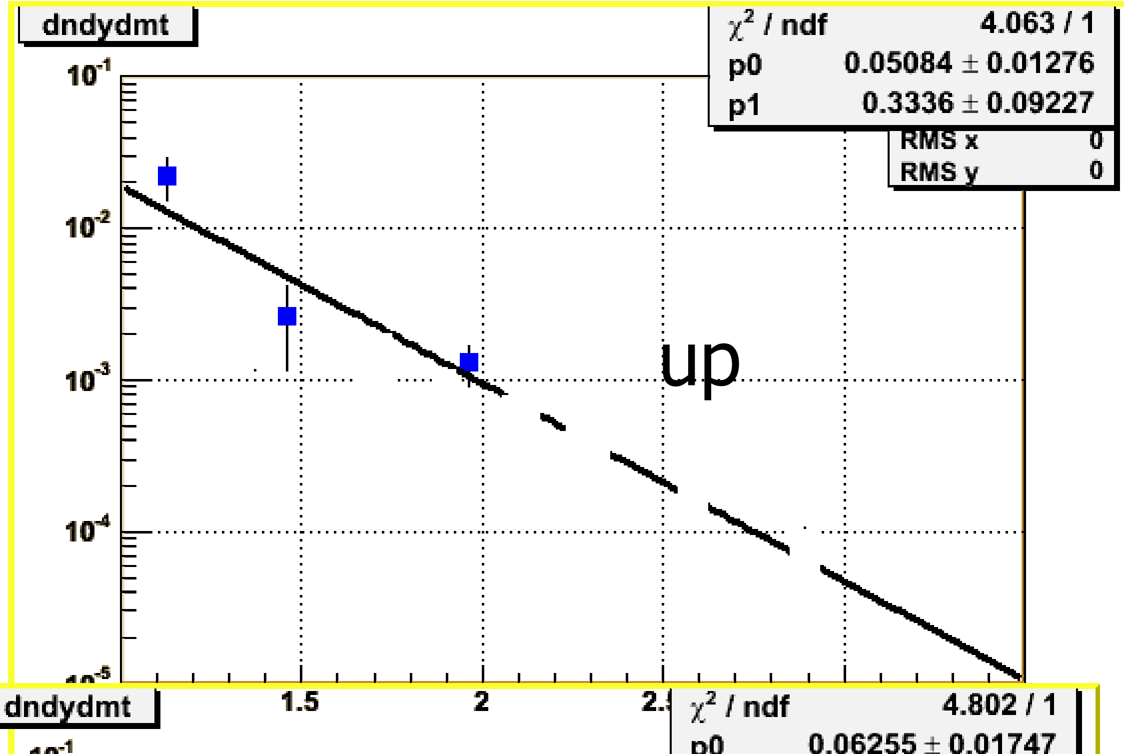
Up

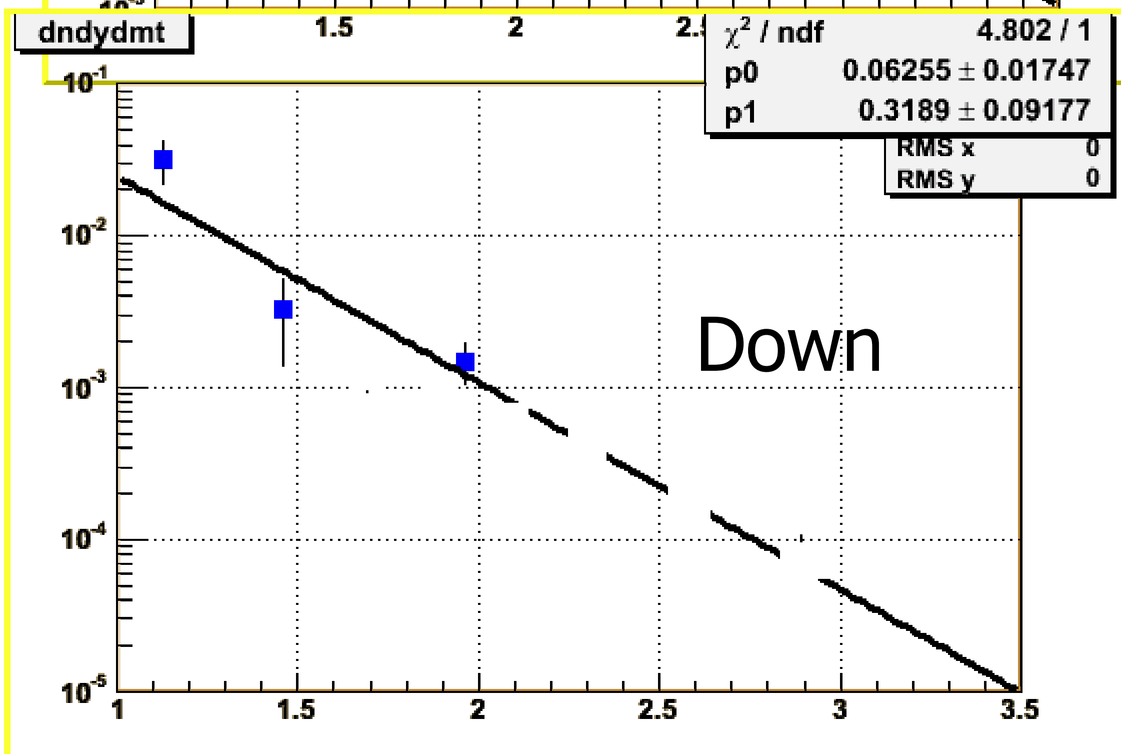
mt-m	N	back	sqrt(b	ACC	TRIG	dy	dmt	br	dndydmt	er
0-0.25	60	342	18	0.0098	0.232	1.2	0.25	3.0E-04	1.56E-01	4.8E-02
0.25-0.75	29	272	16	0.0070	0.499	1.2	0.5	3.0E-04	2.46E-02	1.4E-02
0.75-1.25	27	64	8	0.0072	0.691	1.2	0.5	3.0E-04	1.61E-02	4.8E-03
1.25-5	17	45	7	0.0122	0.782	1.2	3.75	3.0E-04	7.04E-04	2.8E-04
TOTAL	126	706	27	0.0086	0.406	1.2	1	3.0E-04	5.34E-02	1.1E-02

DOWN

mt-m	N	back	sqrt(b	acc*pid*	trigg e	delta y	dmt	br	dndydmt	er
0-0.25	60	342	18	0.0098	0.189	1.2	0.25	3.0E-04	1.92E-01	5.9E-02
0.25-0.75	29	272	16	0.0070	0.454	1.2	0.5	3.0E-04	2.70E-02	1.5E-02
0.75-1.25	27	64	8	0.0072	0.650	1.2	0.5	3.0E-04	1.71E-02	5.1E-03
1.25-5	17	45	7	0.0122	0.762	1.2	3.75	3.0E-04	7.23E-04	2.9E-04
	126	706	27	0.0086	0.363	1.2	1	3.0E-04	5.97E-02	1.3E-02

- The variation in the yield goes from .051 to .063 or about 23%. This is the full extent. I am uncomfortable assigning the naive 12%. So we assign a systematic error in the yield of 20%
- The variation in the inverse slope 0.319 to 0.334 or 5%. This seems small. I then allow only the first point to fluctuate up and down by 20% - assuming that the turn on changes. This changes the inverse slope between 280 and 380. So I assign as systematic error to the inverse slope of 50/320=16%.





Systematic due to the bin center

- As mentioned previously, the points are put at their weighted bin center which is found by doing the fits iteratively so that finally the point is placed at a location which is the weighted bin center of a bin with a slope of 320 MeV. The fit is then done to all the points (3) and a value of 326 MeV is returned. Suppose we force the bin center to be found assuming that the slope was 250 MeV, or 500 MeV? The answer is:
  - Setting T to 200 returns: T=331 and dNdy=.050
  - Setting T to 500 returns T=324 and dNdy=.058
  - So this is possibly a ~10% systematic
- Because of the iterative process, I don't believe it is necessary to add this in.
- However a systematic error I have alluded to, but have not really quantified is if the dndmt is really a power law (as we might expect) and not an exponential.
- This is another reason I have been generous with the sytematic errors.

Run-by-Run

- For the run by run variation we follow the lead of the J/psi analysis and use the fact number of electrons per trigger fluctuates by about 2.5%. This leads to variation in the yield of about 5%.

Final numbers

The systematic error is dominated by the error on the background signal extraction of about. Summing up the contributions to the systematic error gives

1) For dN/dy ~ 1%2%$\oplus$45% $\oplus$ 20% $\oplus$ 5%=50%
2) For the inverse slope ~ 1%+2%+50% $\oplus$ 16%=53%

Giving finally

dN/dy=.056$\pm$.015(stat) $\pm$50%(syst)

T=326 $\pm$94(stat) $\pm$53%(syst) MeV

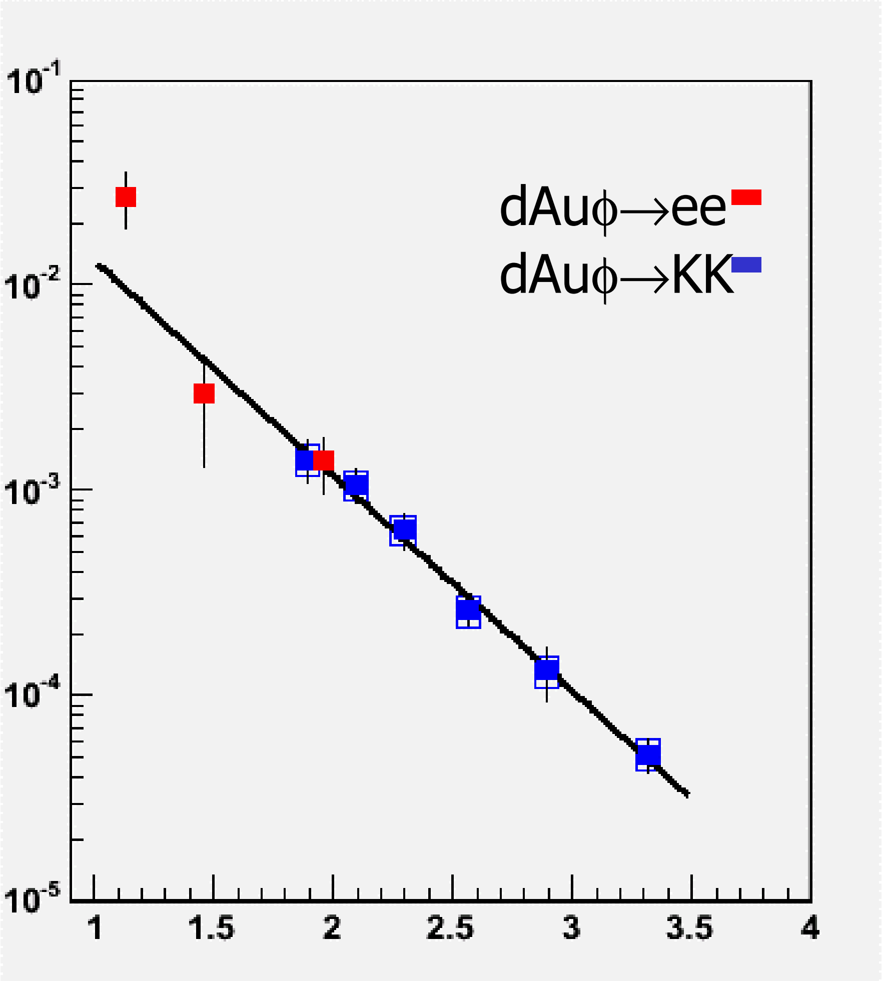
Request prelim

Summary of systematic errors

	Effect on dndy	Effect on T
Slope assumption effect on acceptance	1%	1%
Slope assumption effect on ert eff	2%	2%
Background subtraction and counting	45%	50%
ERT fluctuations	20%	16%
Run-by-run	5%	-
Total	50%	53%

Comparison to KK

- The red points are the fit points of this analysis, the blue are from the KK analysis. An overall fit gives a good chisq



$\phi \to$KK min bias

dN/dy = 0.0468 +/- 0.0092(stat) (+0.0095,-0.0092) (syst.)

T (MeV) = 414 +/- 31 (stat) +/- 23 (syst)

Overall fit
dN/dy~ .0485
T~408
χ^2/DOF=6.7/7

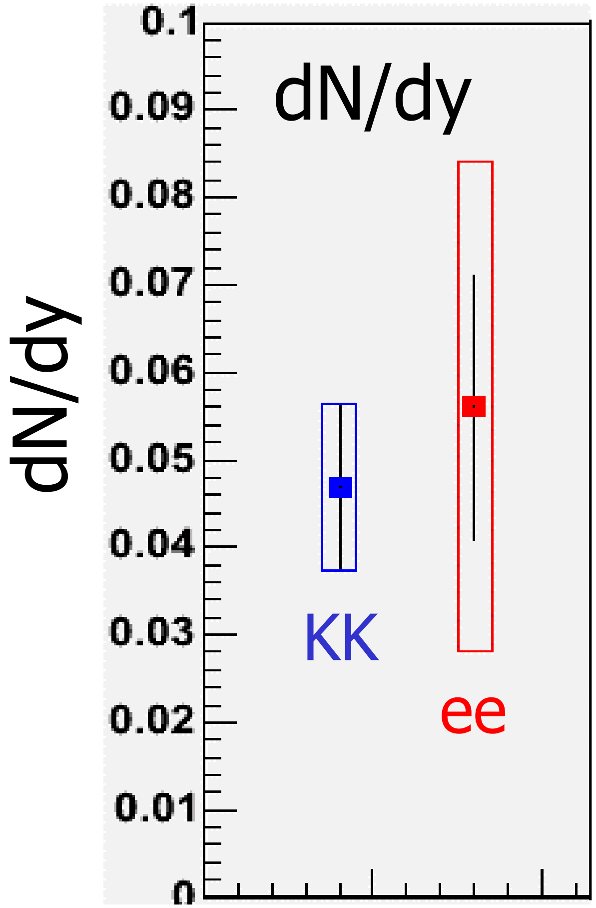
Compare ee with KK results

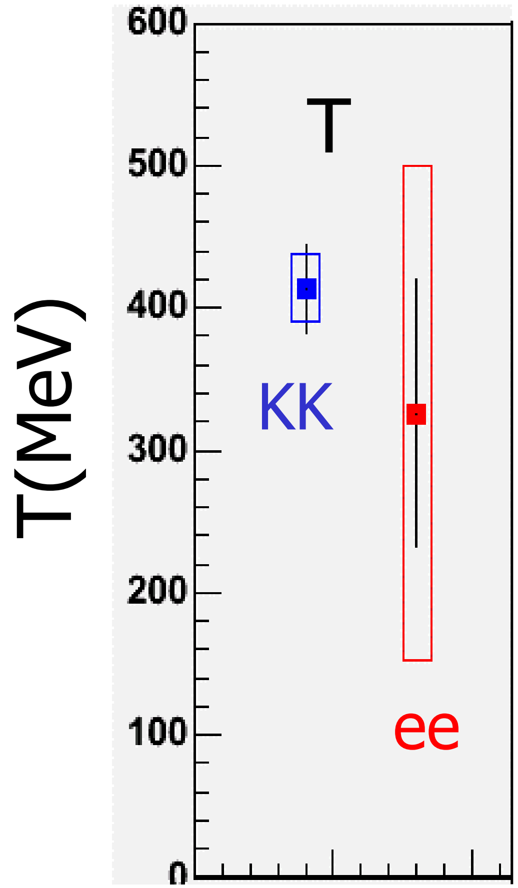
KK channel
dN/dy = 0.0468 +/- 0.0092(stat)
(+0.0095,-0.0092) (syst.)

ee channel
dN/dy=.056±.015(stat) ±50%(syst)

KK channel
T (MeV) = 414 +/- 31 (stat)
+/- 23 (syst)

ee channel
T=326 ±94(stat) ±53%(syst) MeV

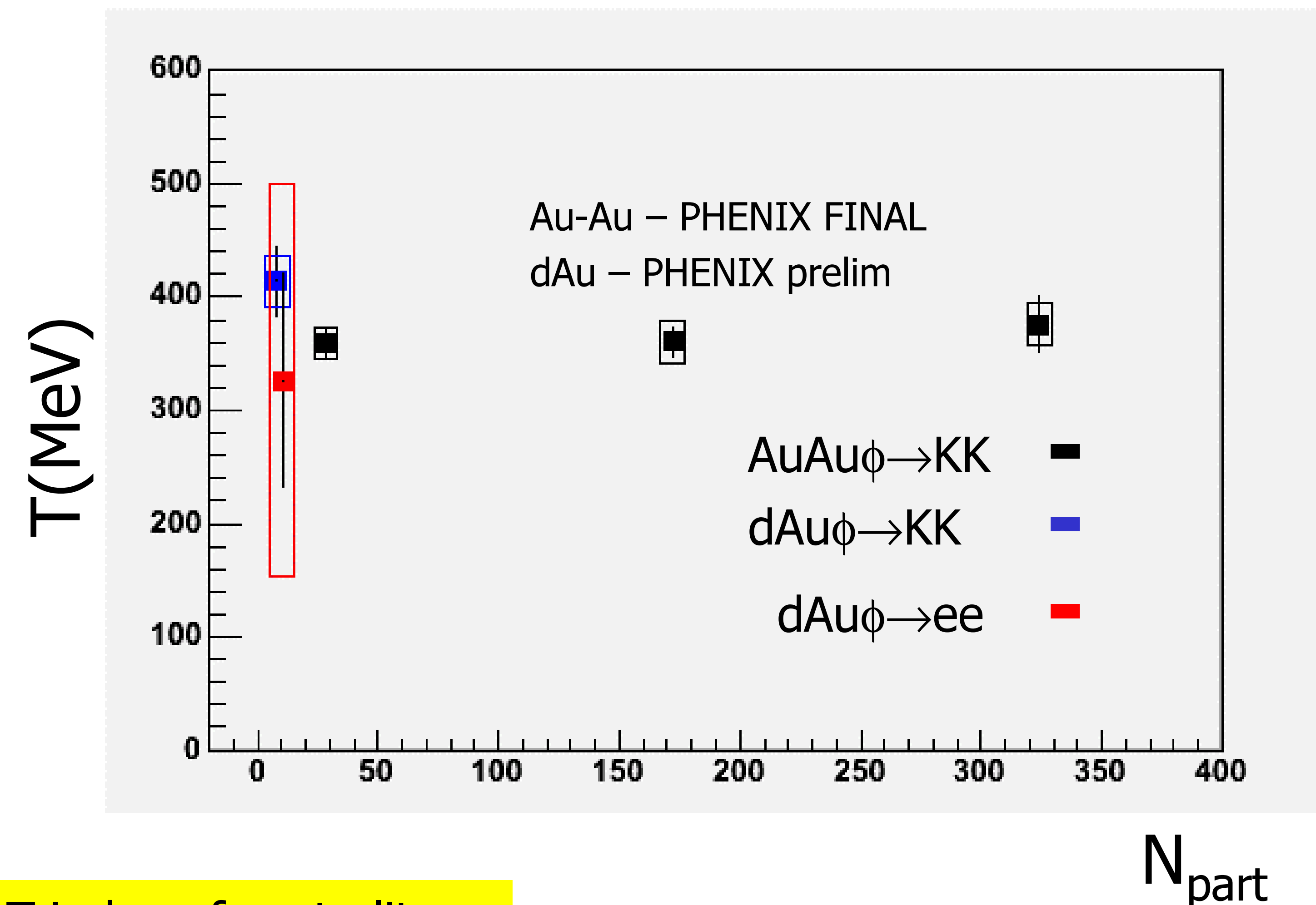




- Yields consistent with each other
  - BR in normal ratio

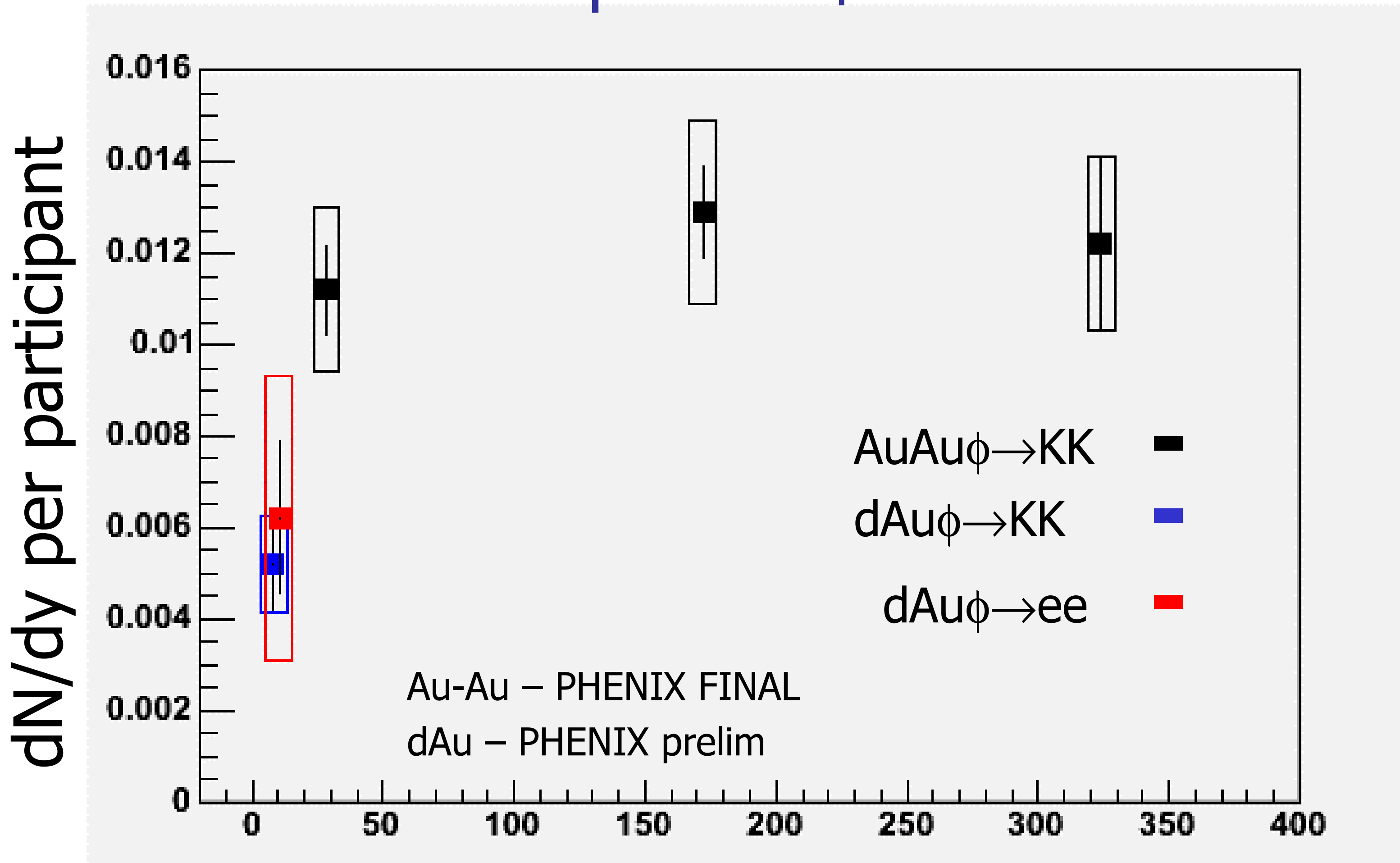
PHENIX preliminary

N_{part} dependence of T



T indep of centrality

dN/dy per N_{part} (N_{part}~9)

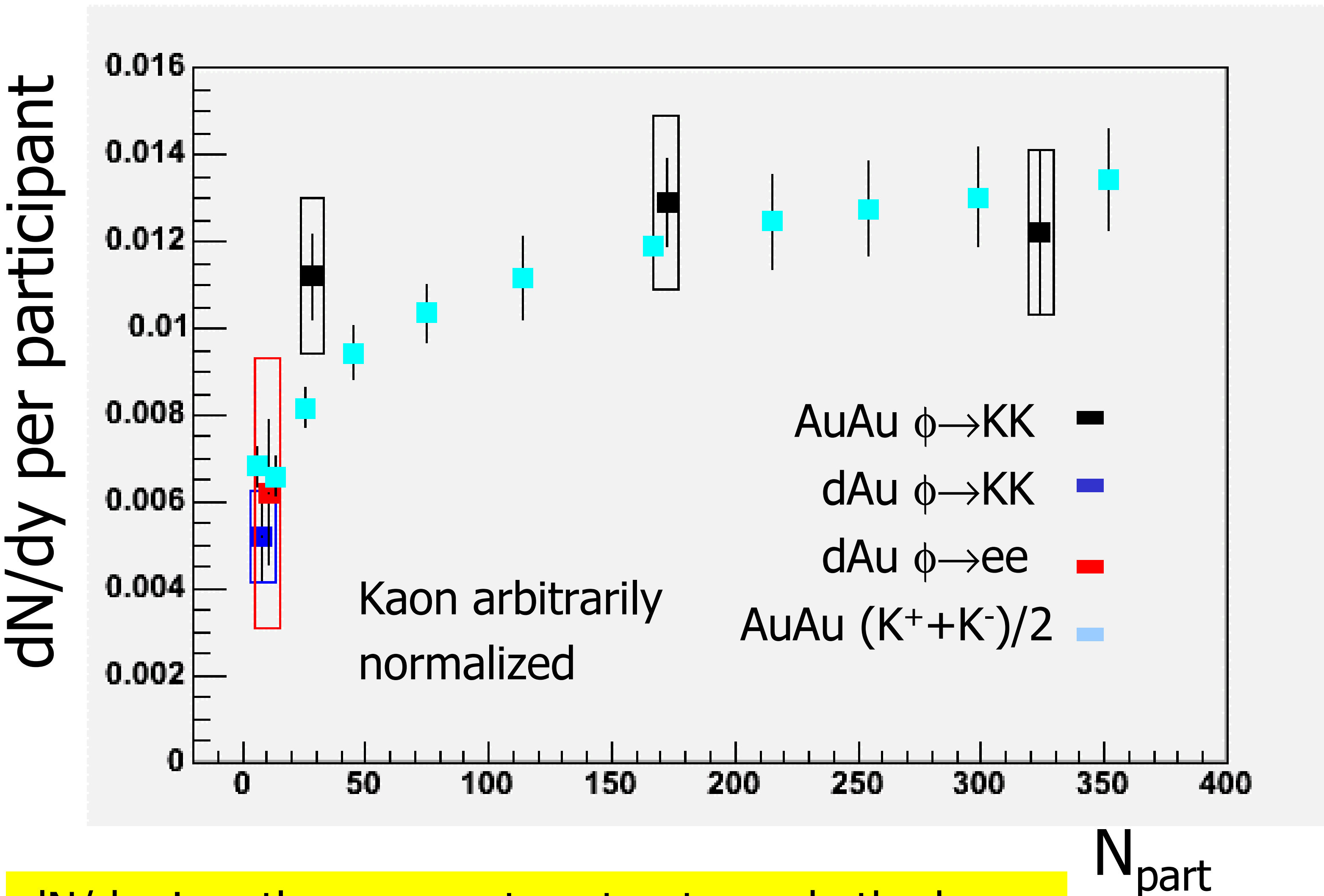


dN/dy rises than seems to saturate

N_{part}

Add kaons

AuAu K – published (nucl-ex/0307022)
Au-Au phi to KK– PHENIX FINAL
dAu – PHENIX prelim



dN/dy rises than seems to saturate as do the kaons

Conclude

dN/dy=.056±.015(stat) ±50%(syst)

T=326 ±94(stat) ±53%(syst) MeV

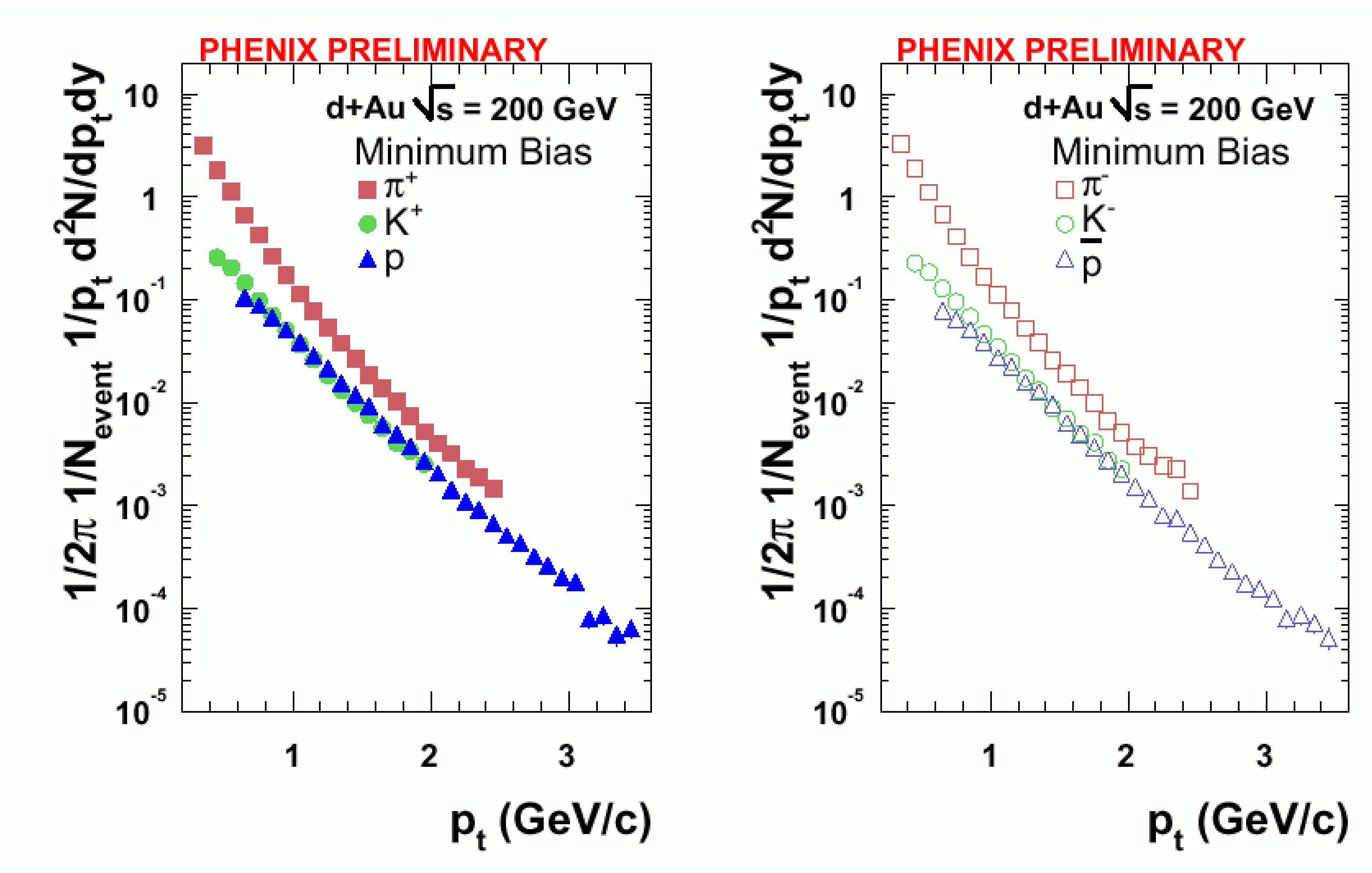
A first measurement has been made of the phi to ee channel. Within large error bars it agrees with the KK result.

In order to pin down the yield and inverse slope we will need to

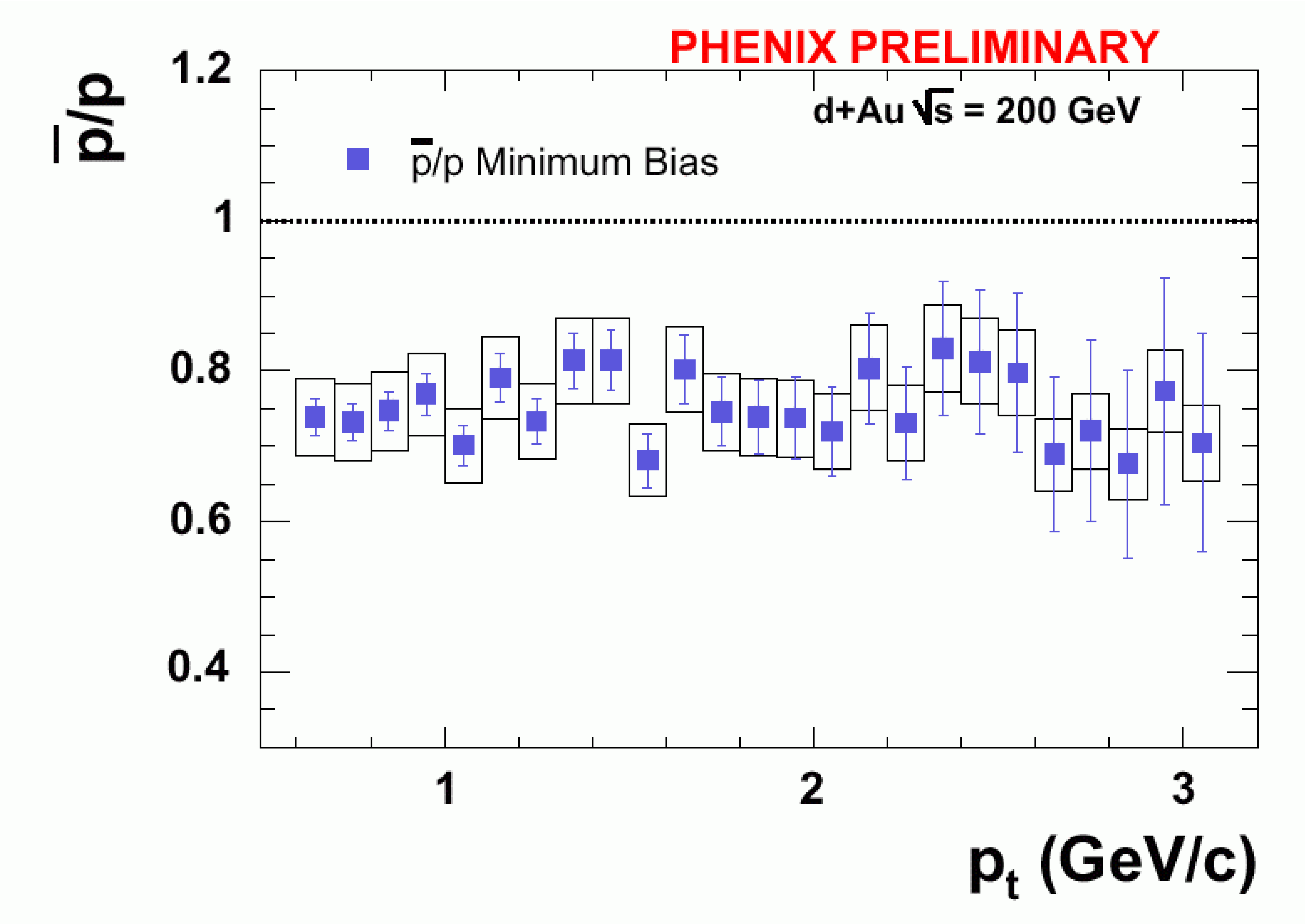
1) Use the 800 MeV threshold data to increase the data at higher mt. ~2x data?
2) Understand the backgrounds to get a more robust subtraction so that we are not dominated by counting and backgrounds
3) Understand the turn on of the ERT since much of the signal comes in on the rising edge of the ERT

ADDED notes

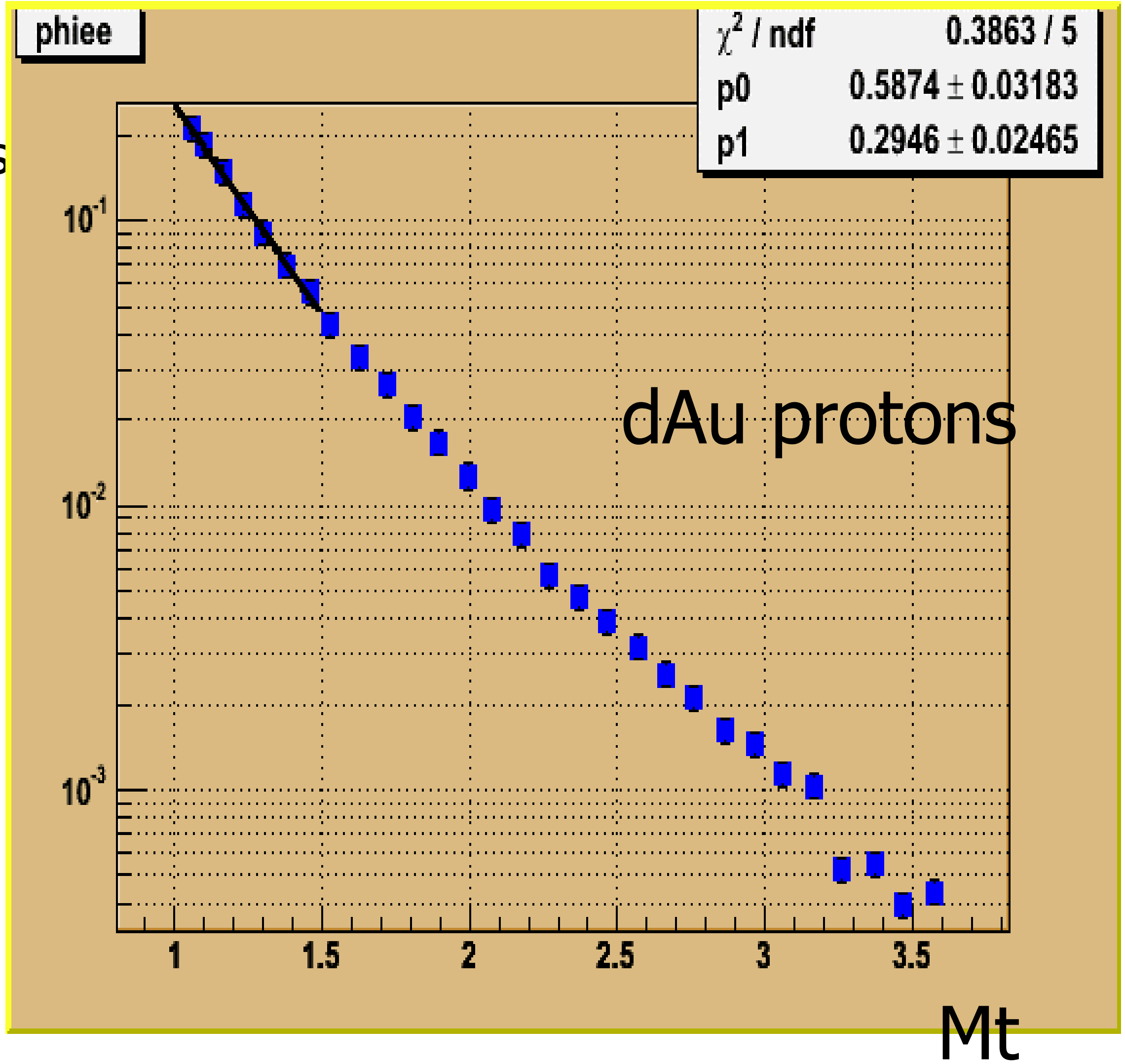
- A inverse slope consistent with Au-Au is not consistent with a naïve flow picture. What do we expect from the proton distribution in dAu?



Protons/antiprotons have same pt behavior – fit protons

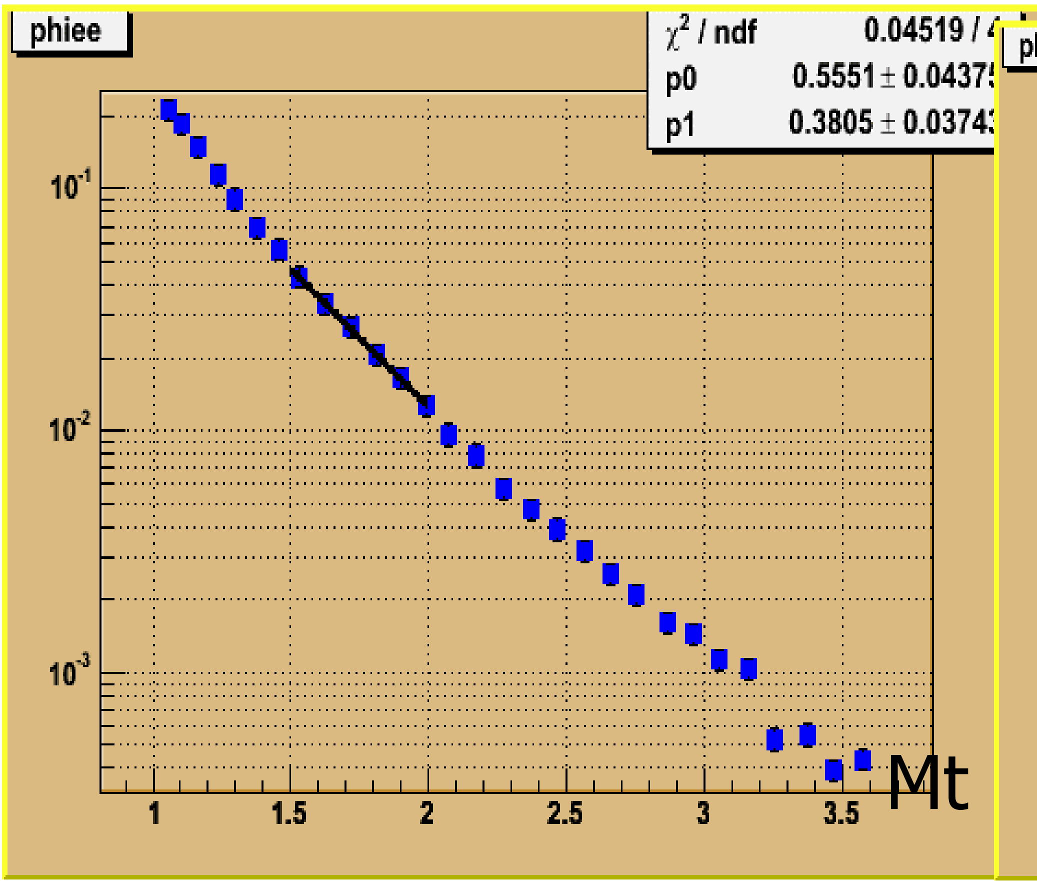


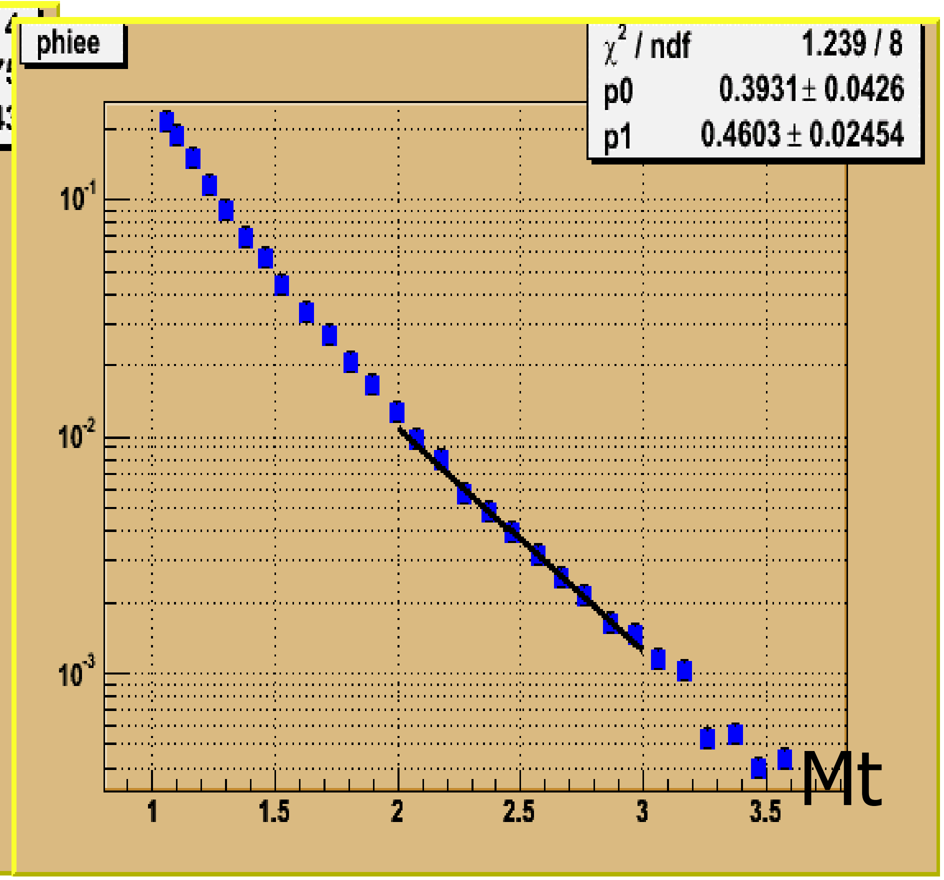
- Pulll off points from pt distribution of protons
- Convert to mt
- Fit to exponential
- It doesn’t fit (I guess we should have expected this)
- Fit low mt (1-1.5 GeV)
- T~300 MeV



- mid mt=1.5-2, T=380
- High mt=2-3, T=460 (consistent now with dipali)

- So depending on where you fit you get T=300 to 450





The fact that it may be a power law fit means that my bin centering procedure is wrong since my assumed distribution (an exponential) is wrong. In fact, for a very wide bin, I do not know where to put the point!. if I put the point at 3.2- the midpoint is actually at 4.125) I get fits to an inverse slope of ~ 300-350. So both because I have have to fit different regions with different slopes, and because I have a very wide bin, I chose to kill the last pt bin. You might argue I don't have a good signal there anyway.

numbers

- dAu phi to ee PHENIX prelim

- dN/dy=0.056 (0.015)(stat) (50%)(syst)
- T=326 (94)(stat) (53%)(syst)

- mt bins
- mt-m0 bins ={0.,0.25,0.75,1.25}
- y=1/2pi/mt dN/dmt/dy

- <mt> y stat error (y)
- 1.12924 0.0270604 0.00831543
- 1.46141 0.00294044 0.00163358
- 1.96141 0.00138755 0.000413831

- This file is http://www.phenix.bnl.gov/phenix/WWW/p/draft/seto/pwglight/phiee_annote/phieenumbers.txt